Road Safety Audits

Practical Guide for Road Safety Auditors

(TRACECA Region)

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Document publication supported by

The authors

Brief biographical details of the authors are given at the rear of this document. The authors are very experienced road safety engineers with extensive experience of safety engineering. Between them they have worked in over 70 countries around the world on road safety issues. They have recently reviewed design standards, trained road safety auditors, developed regional road safety audit guidelines in TRACECA region.

The Document

This document has been developed to give practical guidance and examples of bad practices in safety engineering that occur most frequently in TRACECA Region to assist road safety auditors in identifying potential hazards that can occur on their networks. The good practises identified will assist local safety auditors and designers to identify potential ways and solutions to reduce risks at such potentially hazardous locations.

The Organisation

The International Road Safety Centre (IRSC) is a "not for profit" organisation based in Belgrade, Serbia to support low and middle income countries (LMICs) in their efforts to improve road safety in all 5 pillars of the UN Decade Action. It trains officials and organisations in road safety issues and in management development and implementation of National and Local Road Safety Action Plans and programmes. Trainer Courses are offered at IRSC or through partner organisations in country and training materials including textbooks, guidelines, manuals and lecture modules for universities to teach students in all 5 pillars are available from IRSC (more details from www.irscroadsafety.org).

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PREFACE AND ACKNOWLEDGEMENTS TO THE PRACTICAL GUIDE FOR ROAD SAFETY AUDITORS

After almost two decades of experience with Road Safety Audit (RSA) Worldwide, this procedure is now recognized as one of the most efficient engineering tools. RSA is a highly efficient and cost effective engineering tool for improvement of safety on roads. It is much cheaper to identify road safety deficiencies in the process of design than later after construction is completed. The RSAs are among the most cost-effective investments a Road Authority can undertake.

With its EU Directive No. 2008/96 on road infrastructure safety management, published in October 2008, the European Union (EU) made a clear decision that the RSA will be mandatory for the Trans-European Road Network (TERN) in forthcoming years. This Directive contains another tool called Road Safety Inspection (RSI) on safety deficiencies of existing roads. The activity is very similar to the Road Safety Audit in the pre-opening phase of new constructed roads. RSIs are essential for the redesign and upgrading of existing roads and it is done in many countries to give the designers insights and direction for safety improvements. Within this guide Road Safety Inspections are included under the general heading of Road Safety Audits.

Unfortunately, in reality there is little systematic application of RSA at present in TRACECA Region. RSAs that are implemented are mostly pushed by IFIs and implemented by foreign consulting companies. Even when RSAs are undertaken the RSA recommendations are not always implemented by the road authorities. The latest EU funded Project has tried to develop capacity for RSA implementation in each of the countries. Therefore, in TRACECA Region some steps towards RSA implementation have been taken (each country now has several trained auditors, and a Regional Road Safety Audit manual (based on PIARC – World Road Association) has been produced, and certain Pilot road sections have been audited). In some of the countries RSA has been introduced into the legislation as a mandatory procedure).

Education and training of the auditors is the weakest point in the entire RSA chain within the TRACECA Region. The reasons for this are relatively short history of RSA, non-understanding of RSA methodology and procedures and lack of RSA literature in the Russian language. This is why the team of safety engineering specialists, who are acquainted very well with TRACECA Region, prepared this Practical Guide for Road Safety Auditors in TRACECA Region to help present and future auditors in their work.

This Practical Guide for Road Safety Auditors (PGRSA) is based on actual traffic situations identified as road safety deficiencies and best international practice and proposals for improvement (treatment). As TRACECA Region contains important transport links (corridors) connecting China and Europe, harmonization of road standards and elimination of potential risks for the road users are of utmost importance. This is why this Practical Guide for Road Safety Auditors is based on the existing RSA Manuals from the Region while also applying a common approach to RSA based on PIARC (World Road Association) guidance. This will ensure that similar approaches are applied to RSA related improvement of road infrastructure (RSA Reports) in all TRACECA Countries.

Special attention has been given to the attempt to make the PGRSA user friendly. There are plenty of illustrations from TRACECA Region which will help users to easily understand typical road safety deficiencies and to select appropriate treatments.

This document draws on the more comprehensive guidelines and manuals on Safety engineering mentioned in the acknowledgements but deliberately focuses only on these issues of direct relevance to road safety auditors and to the road safety reports that they have to write.

A number of other sister documents will be produced in due course on other aspects of safety engineering to provide guidance and advice in other specific aspects of safety engineering.

ACKNOWLEDGEMENTS

This Practical Guide for road safety auditors in TRACECA Region builds to a large extent on international best practice, direct experience of the authors in TRACECA countries and draws upon detailed guidance and concepts in the 3 key publications indicated below:

1. "Towards safer roads in developing countries", a guide for planners and engineers, developed by TRL, Ross Silcock partnership and ODA in 1991,
2. "Catalogue of design safety problems and practical countermeasures", developed by World Road Association (PIARC) in 2009 and
3. "The handbook of road safety measures", written by Rune Elvik and Truls Vaa, in 2004.

The above 3 documents provide much more detailed guidance on all key aspects of safety engineering and authors recommend that road engineers should use these in planning and operation of roads to ensure safer road networks.

This particular document is aimed specially at the needs of safety auditors in TRACECA Region and has addressed only the main issues of relevance to them and their tasks in preparing safety audit reports.

The authors have drawn as necessary on these 3 documents and adapted the ideas and concepts to local circumstances.

We are grateful to the authors of the original documents for sharing their experience via these documents.

All photographs used as illustration of the problems, or as best practices are provided by authors.

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INTRODUCTION

It is a well-known fact that in almost all countries in the world road crashes are a serious social and economic problem. Different measures and programs have been developed to reduce the number of casualties on the roads. On an international level, the United Nations, World Health Organization, International financial institutions (especially IBRD, ADB, EBRD, EIB, IADB, AfDB and ISDB) and some specialized NGOs (PIARC, ETSC, PRI, SEETO, etc.) represent high quality stakeholders for global road safety improvements.

In most countries, road design guidelines are applied which in most cases include implementation of road safety issues. Despite this, crashes still occur on new roads. There are several reasons for this. Firstly, design standards often contain minimum requirements regarding road safety and sometimes a combination of these elements can lead to dangerous situations. Furthermore, it is not always possible to comply with the standards. Sometimes, especially in built-up areas or in difficult terrain, there are reasons which make the application of the standards impossible or too costly a solution.

A number of techniques and processes have been developed in the last two decades for improving road safety infrastructure. One of them is *Road Safety Audit (RSA)* which is now recognized as one of the most efficient engineering tools. With the Directive of the European Parliament and of the Council no. 2008/96 on road infrastructure safety management, published in October 2008, the European Union made a clear decision and instruction that road infrastructure should be an important part in the road safety chain. It is clear that among other Road Safety Management tools RSA will be mandatory for the Trans-European Road Network in the forthcoming years and IFIs (WB, EIB, EBRD, ADB, Islamic Bank, etc.) are already extending the application of the Directive via their Projects to the TRACECA Countries. RSAs will have to be performed not only during the design process of new roads but also ahead of major rehabilitations or upgrading of existing roads to detect existing safety deficiencies.

Undertaking of RSA is important for road safety because a formal RSA Report should identify the existing and potential road safety deficiencies and, if appropriate, make recommendations aimed at eliminating or reducing these deficiencies. With the audit process, it is possible to reduce the number and severity of traffic crashes by improving the road safety performance.

The pool of road safety specialists who prepared these guidelines were working in TRACECA countries and had an opportunity to see different road safety deficiencies on major road networks. The need for such a Practical Guide was identified during the observation of typical road safety deficiencies in TRACECA region and during attempts to implement internationally recognized and proven road safety treatments (countermeasures).

Therefore, the aim of the Practical Guide is to be strong and illustrative support for previously trained and future/prospective road safety auditors in the TRACECA region. The Practical Guide follows the PIARC (World Road Association) approach concerning classification of identified road safety deficiencies into 8 broad groups or categories:

- Road function
- Cross section
- Alignment
- Intersections
- Public and private services; service and rest areas, public transport
- Vulnerable road user needs
- Traffic signing, marking and lighting
- Roadside features and passive safety installations

Apart from typical road safety deficiencies, this Practical Guide contains three separate chapters:

- Temporary signing and marking at Work Zones
- Accident type sketches
- Potential crash reduction via various countermeasures.

Before giving a detailed presentation of typical road safety deficiencies, it is necessary to state a few basic facts about RSA.

➢ WHAT IS ROAD SAFETY AUDIT (RSA)

RSA is a well-known internationally used term to describe an independent review of a project to identify road or traffic safety deficiencies. It is a formal examination of a road or a traffic project and can be regarded as part of a comprehensive quality management system. For new roads, RSA is a pro-active approach with the primary aim to identify potential safety problems as early as possible in the process of planning and design, so that decisions can be made about eliminating or reducing the problems, preferably before a scheme is implemented or accidents occur. However, it may also be a reactive approach for detecting safety deficiencies along existing roads as a start for rehabilitations.

The most common definition of RSA is: "*A formal road safety examination of the road or traffic project, or any other type of project which affects road users, carried out by an independent, qualified auditor or team of auditors who reports on the project accident potential and safety performance for all kinds of road users*", as stated in The Road Safety Audit Manual of the World Road Association (PIARC).

➢ AREA OF APPLICATION

RSA can be undertaken on a wide range of projects varying in size, location, type, and classification. The types of projects that can be audited are categorized under the following headings:

- function in the network (International roads, Main roads, Regional and Local roads)
- traffic (motor vehicles only or mixed traffic with non-motorized or slow agricultural traffic)
- position - location (outside or inside built-up area).

RSA is recommended to be taken for all new designs of roads and their major rehabilitation as well.

The RSA could be conducted as follows:

- on new roads, motorways, highways and other road surroundings/equipment,
- before and during reconstruction and rehabilitation,
- inside and outside built-up areas.

➢ STAGES OF ROAD SAFETY AUDIT

According to the international best practice and Regional Road Safety Audit Manual for TRACECA Countries (2014), RSA should be conducted in four different stages[1]:

Stage 1: draft (or preliminary) design,
Stage 2: detailed design,
Stage 3: pre-opening of the road and
Stage 4: early operation, when the road has been in operation for some time.

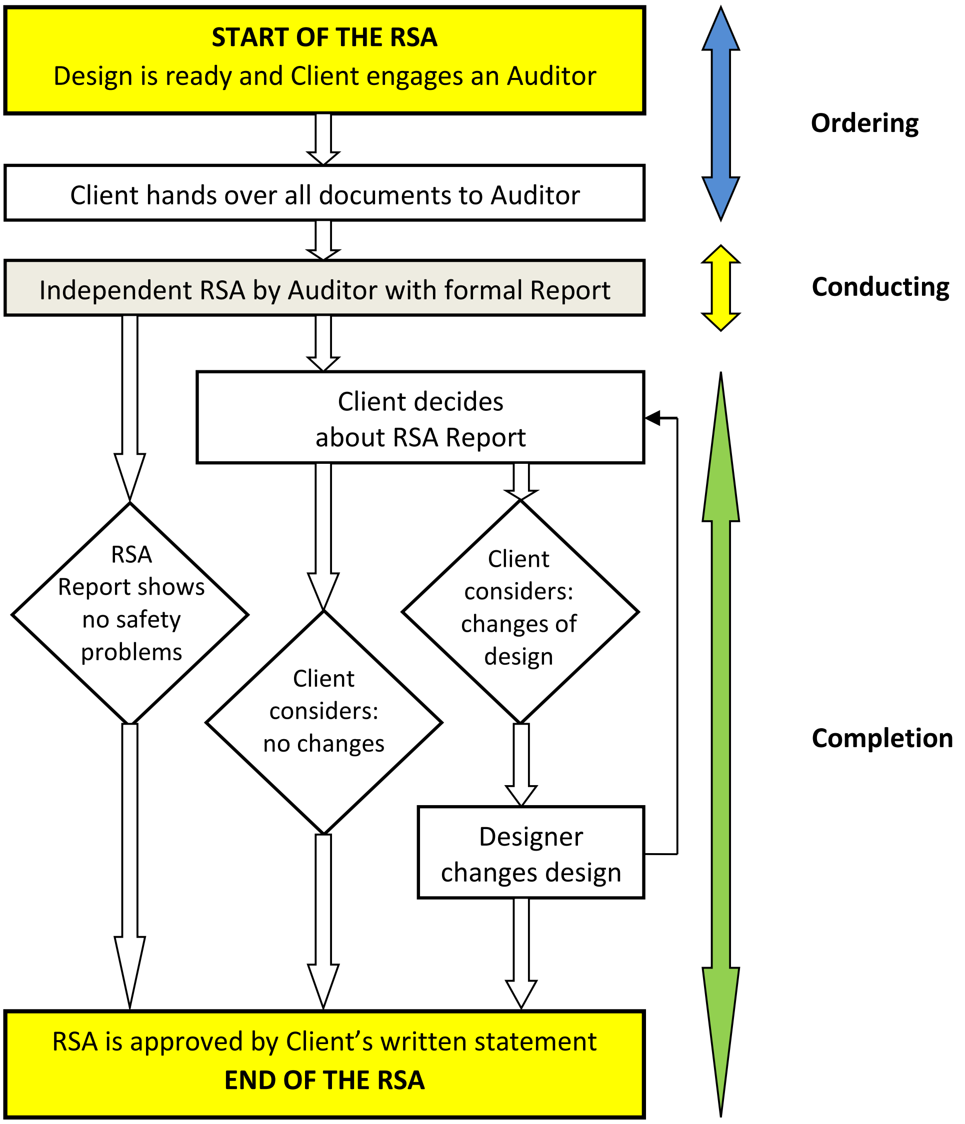
➢ ROAD SAFETY AUDIT PROCESS

[1] In some countries an additional 5th stage is introduced before stage 1 during planning to ensure that route planning, junction strategy etc. does not cause future potential road safety problems.

As a relatively new road safety procedure, RSA should have efficient organizational structure and with clear responsibilities. The general RSA procedure will include three main phases:

- ordering,
- conducting and
- completion.

The following chart (Figure I1) describes the typical RSA process.



➢ **QUALIFICATION OF ROAD SAFETY AUDITORS**

It is important that the auditor has extensive experience in road safety issues.

General expectation is that RSA Team Leader (TL) should have completed relevant university education preferably with Master's degree in a relevant topic such as Traffic Engineering and have significant experience in road safety engineering (design) and/or road traffic crash investigation. Minimum requirements for RSA Team Leader should be at least five years of working experience in the field of RSA and minimum 3 RSA Reports written in the last two years. In addition to this, TL should possess a certificate of competence (Licence issued by a recognised institution).

RSA Team Members (TM) should hold at least Bachelor’s degree and minimum of three years of experience in road safety engineering (design) and/or road traffic crash investigation.

Auditors should possess driving licenses and have good knowledge of Road Design Standards, Traffic Safety Law and Law on Roads. The knowledge of other related standards is highly desirable.

To ensure the quality of the audit, auditors should undergo initial training, resulting in the award of a certificate of competence and should take part in further periodic training courses. The training should include site inspections of existing roads known for a high rate of accidents from police reports to get an understanding and picture of safety deficiencies in design.

In case where audits are undertaken by teams, at least one member of the team should hold a certificate of competence.

It is important to note, that this Practical Guide is not intended to be seen as a detailed design manual. It is just a collection of the most common types of design failures and suggested ways to overcome these.

1 ROAD FUNCTION:

1.1 ROADS WITH MIXED FUNCTION (LINEAR SETTLEMENTS)

Problem

Mixture of road functions (usage of the road as fast distributors for fast longer distance motorized traffic and as a route for slow local traffic) causes one of the major road safety problems especially in low and medium income countries (LMIC), such as in most of TRACECA Region.

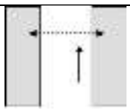
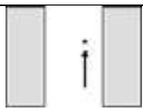
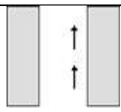
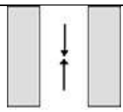
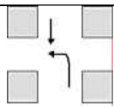
This is one of the common problems in almost all of TRACECA countries where the rate of expansion of isolated communities along a road can rapidly reduce the effectiveness of a nationally or regionally important route as a result of the local traffic activities overwhelming the through route function of the road.

In such cases, the role of the road in the road hierarchy becomes confused. While the road is passing through settlements (without existence of by-pass) can it keep its geometry unchanged? Can it be called International/Regional/National road, or does it become a street? This, simple planning (designing) mistake of local administrations, can cause tremendous problems in road safety. Once intense development has been allowed it is very difficult to achieve improvements without major reconstruction on a new alignment. Often even when a bypass has been built, the village often over time extends out across to the new road. This is mainly an issue of access control (See Ch. 1.2).

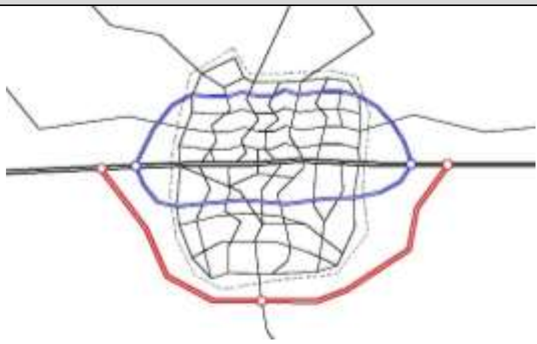
Examples of unsafe designs from TRACECA Region

 Armenia: 3+3 road with median	 Uzbekistan: 3+3 road with median
 Kyrgyzstan: Wide road without median	 Turkmenistan: Wide road without median

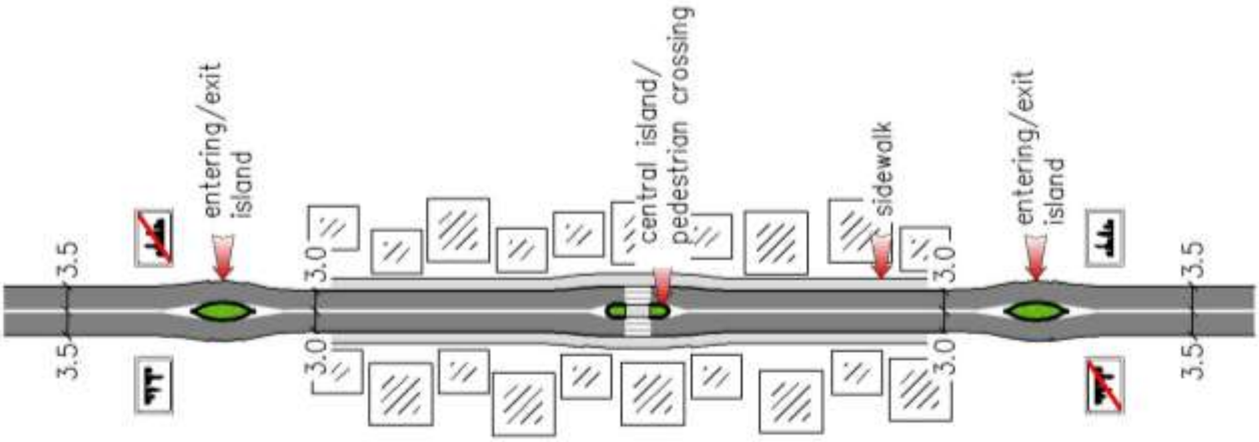
Typical accidents:

 Pedestrian crossing street outside a junction	 Pedestrian in the road	 At least two vehicles - same direction - rear end collisions	 At least two vehicles - head on collision in general	 At least two vehicles - same road - opposite direction - turning left (right) in front of other vehicle

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Separation of slow and fast traffic by small distributor roads either between the main road and house or behind those ($$) 2. Construction of by-pass Best but expensive solution with high possibility that one-day a new by-pass will be needed ($$$) If building a bypass, the opportunity should be taken down grade the old road by narrowing it, widening footpaths etc. to deter through traffic using it.	**8 - 30 %** **16 - 33 %** (these figures include accidents on old road network and on by-pass)	 Example of small distributor roads (blue) and by-pass (red) around the built up area
2. Grade separation of long distance and local traffic - Full space separation of fast moving vehicles and local transport. Fast road with access control (grade separated intersections, acceleration/ deceleration lanes, etc.) ($$) - Separation of pedestrians (pedestrian bridges or underpasses with ramps and no steps) ($$)	**20 - 57 %** **13 - 44 %** (including all accidents, with pedestrians and with vehicles)	 Armenia  Tajikistan
3. Changing character of road (from mobility to accessibility) – so it act as a street. Main task is to “kill” the speed - Building of entering/exit islands or roundabouts ($$) - Narrowing of the road ($) - Implementation of different traffic calming measures ($)	**11 - 47 %** **2 - 10%** **5 - 12 %** (including narrowing of the road)	 Example of speed reducing entering/exit island to/from the built up areas

Sketches (with dimensions):



Example of road elements within the built up areas

1 ROAD FUNCTION:

1.2 ACCESS CONTROL

Problem

Along interurban roads strong access control is the basis of road safety. The clear legal regulation of developments along the road in road legislation is a must for avoiding development of liner settlements. But access control is also a safety issue for urban roads.

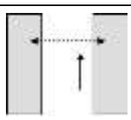
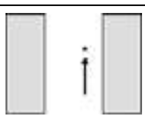
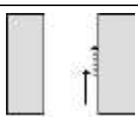
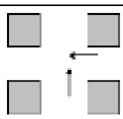
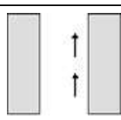
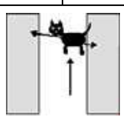
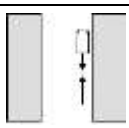
Limiting of the number of access points to the road/street is usually done for two reasons. The first is to limit the number of side roads joining a major route, in order to reinforce a road hierarchy and to concentrate potentially dangerous turning movements at a single junction which can be properly designed for such movements. The second reason is to reduce through traffic in a residential area, by making the route into and through an area tortuous and long. Only those requiring access will continue to enter.

These situations should be predominantly urban, but in TRACECA region there can be examples of trading posts on major regional/rural routes where a number of direct access points occurs at closely spaced intervals. Such locations are often accident black spots, due to uncontrolled turning movements and pedestrian activity. Closing most (or all but one) of the accesses, and one of the exits turning movements could be concentrated on one single point where other measures can be applied to deal with them more safely.

Examples of unsafe designs from TRACECA Region

 Armenia	 Kyrgyzstan
 Georgia	 Kyrgyzstan

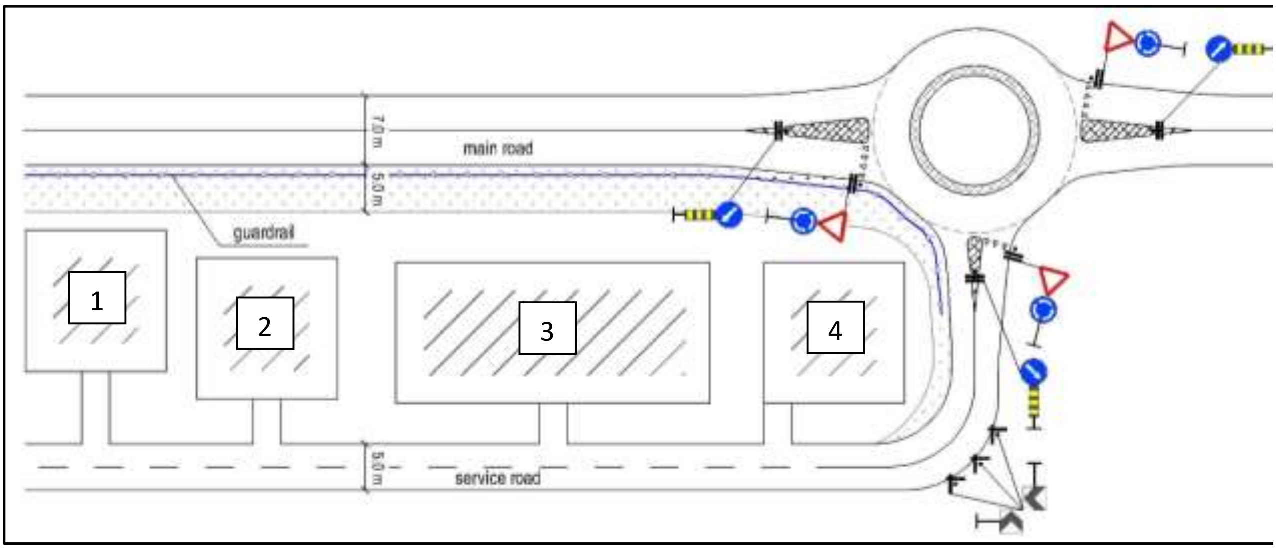
Typical accidents:

 Pedestrian crossing street outside a junction	 Pedestrian on the road	 Pedestrian walking along the road	 At least two vehicles - crossing (no turning) - different	 At least two vehicles - same direction - rear end collisions
 Single vehicle accidents with animals		 At least two vehicles - opposite direction no turning - reversing		

1.2 Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Closing of direct access to road and construction of parallel service road which will collect traffic and connect to main road at only a few better designed junctions ($$$)	**8 – 30 %**	
2. Traffic signage and traffic calming measures: - Traffic lanes narrowing on the main road ($$) - Traffic stream channelization ($$) - Pedestrian crossings with refugee islands ($) - Guardrails ($) - Lighting ($$) - Warning and speed limit signs (reduction in speed limit) ($)	 **15 - 37%** **15 - 37%** **3 – 21 %** No reliable data in this context **17 – 64 %** **13 – 16 %**	 Access to/from buildings prevented by a wall and only allowed at a single location

Sketches (with dimensions):



Example of parallel service road and roundabout for connection to main road

(Traffic from buildings 1,2,3,4 not permitted to join the main road directly
but is controlled via the service road and brought to a better safer junction)

1 ROAD FUNCTION:

1.3 EXCESSIVE SPEED

Problem

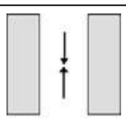
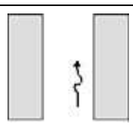
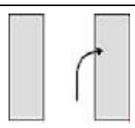
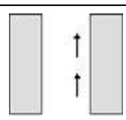
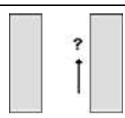
Excessive speed and driver inattention are two of the most commonly occurring contributory factors in road accidents. Long straight road sections, especially, can increase speed (see 2. Alignment). Reducing speed, therefore, is likely to offer substantial safety benefits. In TRACECA region it can be seen that speed limits are widely abused, especially on intercity sections and police enforcement is not seen as frequently on the road. It is clear that self-enforcing physical measures are necessary to encourage, or force, drivers to slow down and obey speed limits. A number of methods have been developed to achieve this. Self-enforcing measures, such as road geometry to discourage particular movements, and speed cameras to deter speeding on intercity roads are possible and desirable treatments/measures.

In a residential area, where city by-passes or separation of long distance and local transport does not exist, through traffic strongly interacts and conflicts with local inhabitants and therefore should be treated in a different way. In this case the road acts as a local street. Therefore, the concept of speed calming devices (bumps), often called “sleeping policemen” should be considered as the cheapest and most effective measure for speed reduction. Other measures can be implemented such as: chicanes, road narrowing, median island, roundabout, etc. Most of these measures should be implemented at the entrance/exit of the settlement and drivers speed be influenced by the changed condition of the road as it passes through the settlement.

Examples of unsafe designs from TRACECA Region

 Azerbaijan	 Kazakhstan
 Moldova	 Ukraine

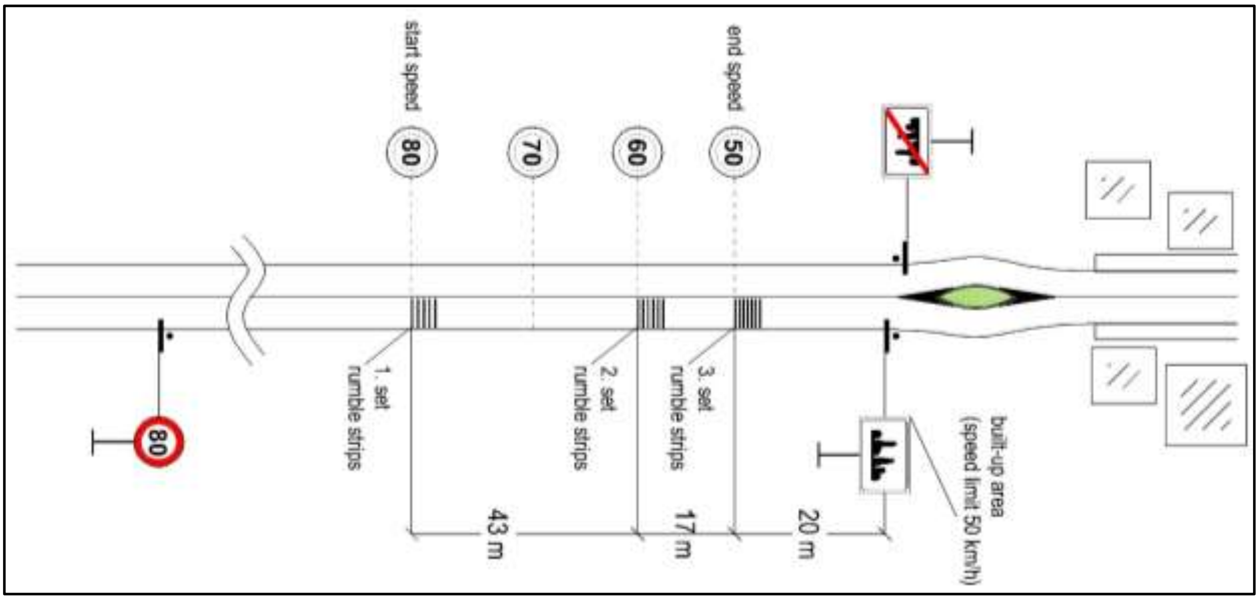
Typical accidents:

 At least two vehicles - head on collision in general	 Single vehicle accidents on the road	 Single vehicle accident - Leaving straight road - either side of the road	 At least two vehicles - same direction - rear end collisions	 Single vehicle accidents with obstacles - others

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. On interurban road section:		 Azerbaijan  Turkmenistan
- speed limit management (reduction in speed limits) ($)	**13 – 16 %**	
- lane width reduction (overtaking traffic lane from 3.75 to 3.50 m) (no costs, savings)	**15 – 37 %**	
- speed cameras ($$)	**16 – 19 %**	
- variable massage signs ($$)	**24 – 62 %**	
- traffic police speed control (stationary speed enforcement) ($)	**5 – 24 %**	
- traffic police patrols (mobile forms of enforcement)	**12 – 20 %**	
2. Through traffic in a residential area (where no by-passes or separation of long distance and local traffic):		 East Europe
- built-up areas entering islands ($$)	**11 – 47 %**	
- narrowing of the road $$	**2 – 10 %**	
- roundabout $$/$$$	**14 – 47 %**	
- central (refugee) island $$	**3 – 21 %**	
- rumble strips $	**25 – 40 %**	
- speed humps $	**42 – 54 %**	

Sketches (with dimensions):



Example of rumble strips on an entrance to built-up area used for speed reduction.
(Rumble strips used to give advance warning before entry point or "gateway" to the urban area where the interurban road becomes a "street" as it passes through the settlement.
Speed reduction can be maintained by sped reduction measures at intermittent intervals on the road as it passes through the settlement.)

2. CROSS SECTION:

2.1 TYPES OF CROSS PROFILES (WIDTH OF THE ROAD)

Problem

A cross section will normally consist of the carriageway, shoulders or kerbs, drainage features, and earthwork profiles. It may also include facilities for pedestrians, cyclists or other special user groups. There is some evidence to suggest that widening lane or carriageway width or widening shoulders up to a certain extent is beneficial in reducing certain types of accidents. However, beyond a certain point it can have negative effects on road safety (users will start using extended width as a regular lane). Dangerous cross sections of express roads and highways are frequently being used in TRACECA region. For example, a four lane road without a crash barrier or two lane road with wide hard shoulders. A road with a wide hard shoulder can sometimes be misused by drivers as a very narrow four lane road, with disastrous results and very serious crashes.

Cross sections, particularly on roads through built up areas, are often not uniform or consistent. Local developments may encroach onto the carriageway because of the lack of effective planning control. In rural conditions cross sections may be reduced at drainage structures causing sudden changes in width.

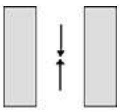
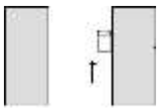
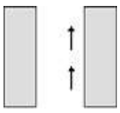
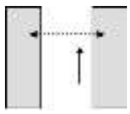
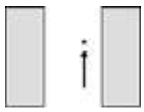
Maintenance of the road in full profile impacts the safety situation. If a pavement width reduces due to the lack of maintenance (water on the pavement, sand, gravel, etc.) or pavement breaking at the edges effectively narrowing the road width, head on collisions or loss of control over a vehicle can occur.

Steep side slopes, introduced for drainage purposes, do not allow a driver to recover in case he leaves the carriageway, and thereby add to the likelihood of an accident. Open channel drains can also increase the probability that driver error will result in an accident.

Examples of unsafe designs from TRACECA Region

 Armenia	 Kazakhstan
 Georgia	 Azerbaijan

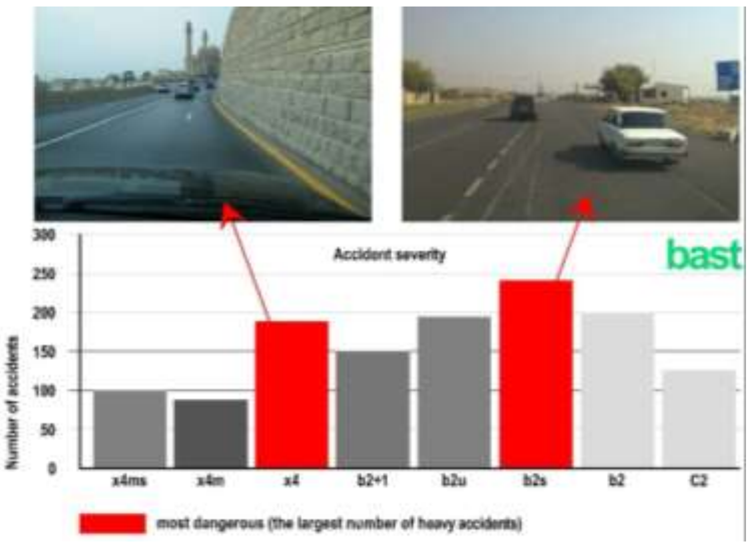
Typical accidents:

 At least two vehicles - head on collision in general	 Hitting parked vehicles on the right (left) side of the road	 At least two vehicles - same direction - rear end collisions	 Pedestrian crossing street outside a junction	 Pedestrian in the road

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Reconstruction of cross section - Changing into one of the safest solutions (motorway cross profile) ($$$) - Introducing of 2+1 cross section with median, where each direction periodically and alternatively given 2 lanes. This gives the opportunity of safe overtaking along 40% of the road length for traffic volumes up to 20.000 vehicles per day) ($$)	**10 – 80 %**	 
2. Road improvements (Rehabilitation) - Installation of medians ($$$) - Reducing the lane width (in built-up areas) - Improving of slopes – flattening side slopes ($$)	 **7 – 24 %** **15 – 37 %** **18 – 46 %**	
3. Better signing and marking - Improved signing – usage of warning signs, speed limit signs and VMS ($) - Improved markings – usage of central hatching, rumble strips, "ghost" islands, etc. ($)	 **10 – 62 %** **11 – 35 %**	

Sketches (with dimensions):



- X4ms = 4x (3,00 to 3,75) metre wide lanes + medium + 1,5 emergency lane
- X4m = 4x (3,00 to 3,75) metre wide lanes + medium
- X4 = 4x (3,00 to 3,75) metre wide lanes No medium!
- b2 = 2 x 3,50-metre wide lanes
- C2 = 2x 3,25-metre wide lanes + speed limit
- b2s = 2x 3,50-metre wide lanes + 2,5m emergency lane: used as four lane roads
- b2+1 = 2x 3,50 metre wide lanes + an overtaking lane alternatively used (regulated by markings, plastic poles or barriers)

Example of cross section influence on accident severity
(BASt – Federal Highway Research Institute in Germany with example of cross sections in TRACECA countries)

2 CROSS SECTION:

2.2 DRAINAGE

Problem

Drainage ditches are an essential part of all roads which are not on an embankment and must be incorporated into most highways. They are designed to take up the expected rainfall but can often be hazardous to vehicles that run off the road. Adequate attention must therefore be paid to the safety considerations of drainage facilities when designing and upgrading highways. Unfortunately, deep and steep-sided drainage channels can result in more damage in the case of vehicles going off the road.

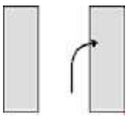
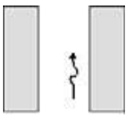
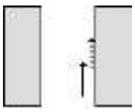
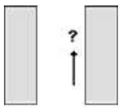
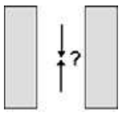
Inadequate maintenance and clearing of debris from drainage channels, especially on the uphill side of the carriageway where large volumes of solid material are often washed down into the ditch, can result in water and debris overflowing onto the carriageway. This results in the potential danger of drivers colliding with debris or aquaplaning.

In many TRACECA areas, rural roads become the main pedestrian routes between adjacent communities and the absence of pedestrian footpaths forces pedestrians to walk along the road, especially if the drainage ditch is of such type (e.g. deep U or V type) which cannot be used as a pedestrian route. Unprotected U and V type ditches present a hazard to motorized vehicles particularly motorcyclists. These types of drainage should be covered as this reduces problems for vehicles, particularly motorcyclists/bicyclists.

Examples of unsafe designs from TRACECA Region

 Tajikistan	 Azerbaijan
 Armenia	 Kazakhstan

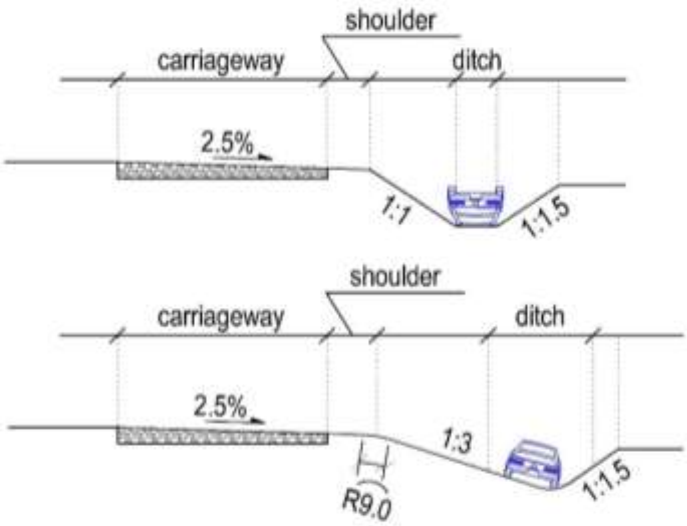
Typical accidents:

				
Single vehicle accident - Leaving straight road - either side of the road	Single vehicle accidents on the road	Pedestrian walking along the road	Single vehicle accidents with obstacles - others	At least two vehicles - opposite direction no turning - others

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Road improvements - Improving of drainage system (adding of ditches with gentler slopes; adding of gutter) ($$$) - Adding of culverts where is necessary ($$$) - Closing of drainage system – piped drainage ($$$) - Usage of special asphalt types at dangerous locations – improving friction coefficient (bridges, etc.) ($$$)	No reliable data No reliable data No reliable data **5 – 55 %**	
2. Usage of traffic signage and equipment - Marking of edge lines as rumble strips (along the deep ditches, in front of culverts, etc.) ($) - Usage of protective devices (guardrails, etc.) ($$)	**11 – 45 %** **41 – 52 %**	
3. Maintenance of drainage system - Cleaning of ditches ($) - Covering of drainage system ($$)	No reliable data No reliable data	

Sketches (with dimensions):



Sleep sided slope increases risks and rollover

Gentle slope increases chances of recovery

Example of gentler slope of ditch and positive effect on traffic safety (preventing rolling over of vehicles)

3 ALIGNMENT:

3.1 VERTICAL AND HORIZONTAL CURVES (CONSISTENCY)

Problem

Unexpectedly tight horizontal curves can lead to accidents as drivers try to drive through them at too high a speed. A similar situation may occur on horizontal curves in other similar hazardous situations, such as steep gradient or after a long straight section where driver is encouraged or misled (by the approach geometry) to think that he can drive at higher speed than is safe for that location. The sight distances associated with larger curve radii may also encourage driver to overtake in unsafe conditions.

It may be difficult for a driver to estimate the sight distance on a curve crest and he may overtake when he doesn't have sufficient length to do so safely. It can be extremely expensive to provide safe overtaking sight distances on crest curves. However, a complete ban on overtaking can be difficult to enforce because of the presence of very slow-moving vehicles, the lack of driver discipline in selecting stopping places, and poor maintenance of road markings and signs.

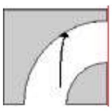
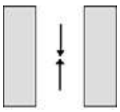
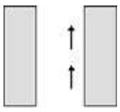
Poor co-ordination of the horizontal and vertical alignments can result in visual effects which contribute to the accidents and are detrimental to the road appearance. Unsafe combinations of horizontal and vertical curvature are likely to be misinterpreted by a driver and may result when horizontal and vertical curves of different length occur at the same location. These situations are particularly dangerous and are unfortunately frequently present in TRACECA region.

In general, interurban main roads of the higher class should have minimum radii of 500 m and the horizontal alignment of classes below should follow the tulip of radii (see below). On the other hand, for human factors the length of straight road sections should be limited to 1.500m to avoiding monotony and sleepiness of drivers combined with speeds far above of the speed limits and to make it easier to judge speeds of oncoming traffic.

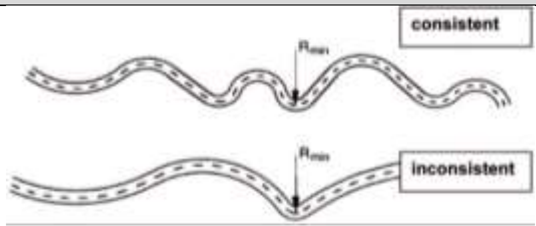
Examples of unsafe designs from TRACECA Region

 Armenia	 Georgia
 Moldova	 Kazakhstan

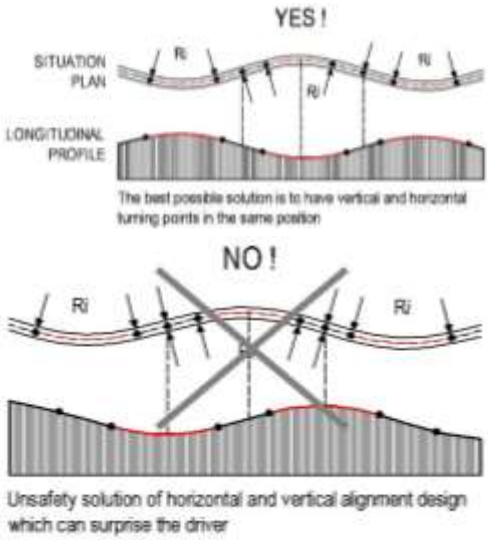
Typical accidents:

 Single vehicle accident in a bend - going either side of the road	 At least two vehicles - head on collision in general	 At least two vehicles - same direction - rear end collisions

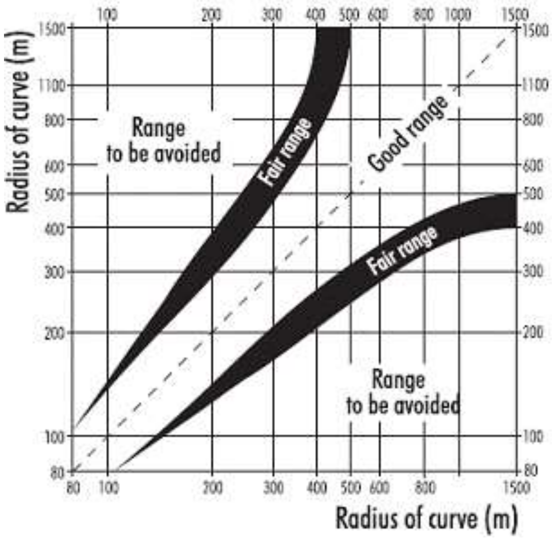
Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustration
1. Reconstruction of curves - increasing the radii of horizontal curve ($$$) - construction of transition curve ($$$) - reducing gradient of vertical curve ($$$) - consistency of alignment (horizontal and vertical curve) ($$$)	 **8 – 55 %** **7 – 15 %** **5 – 38 %** **17 – 28 %**	 An inconsistent alignment with a combination of large with a sudden unexpected small radius horizontal curves surprises the driver
2. Better signing and marking - Better signing (including warning signs, chevron signs, speed reduction and overtaking prohibition signs) ($) - Better marking (including lines as a rumble strip) ($) - Usage of protective devices (guardrails, etc.) ($$) - Lighting ($$/$$$)	 **13 – 16 %** **11 – 45 %** **41 – 52 %** **17 – 64 %**	
3. Improving sight distance in curves - Forward visibility at the insides of curves (open visibility) ($$) - Removing of vegetation ($)	 **6 – 38 %**	

Sketches (with dimensions):



Example of consistency/inconsistency of alignment (horizontal and vertical curves)



The Tulip of radii for rural roads

3 ALIGNMENT:

3.2 SIGHT DISTANCE (VISIBILITY)

Problem

In general, the visibility offered to drivers should be sufficient to identify any necessary course of action and then to perform that action safely. A usual critical requirement is that the driver can stop safely, and this requires the understanding of speeds, reaction times and deceleration rates. Sight distance requirements are thus related to geometric design and speed controls and are inherent in all design standards. Visibility may relate to another road user, or to an object such as a road sign. Conspicuity, i.e. the ease with which the object can be seen, is the most important.

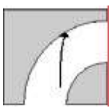
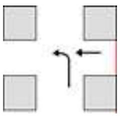
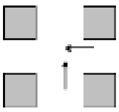
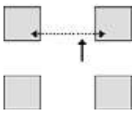
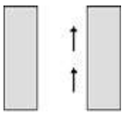
Drivers on the main road should also be able to see vehicles approaching from side roads as early as possible in order to prepare and be able to take evasive action if necessary. This is one of the reasons why recommended visibility splays usually involve the requirement for a vehicle approaching from a side road to be seen before it reaches the stop or give way line. Pedestrians also need to see and be seen and crossing movements are often concentrated at or near junctions. From our human factors research drivers need 4-6 seconds to realize a new situation; this means 300 m ahead if the speed limit is 100 km/h or 200m for 80 km/h.

A common accident problem in TRACECA countries associated with visibility is where a minor road meets a major road at a narrow angle. This encourages vehicles on the minor road to negotiate the junction at speeds higher than is compatible with the visibility available to them. Side roads must be forced by physical geometry to slow down or even to stop at the edge of the main road.
Warning and information signs may be sometimes so sited that they have poor conspicuity, and the detailing of the road may not provide sufficient additional clues as to the hazard or decision ahead.

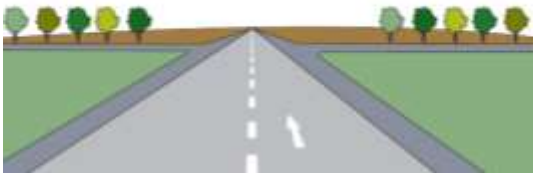
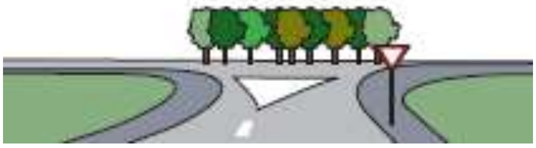
Examples of unsafe designs from TRACECA Region

 Georgia	 Ukraine
 Kazakhstan	 Azerbaijan

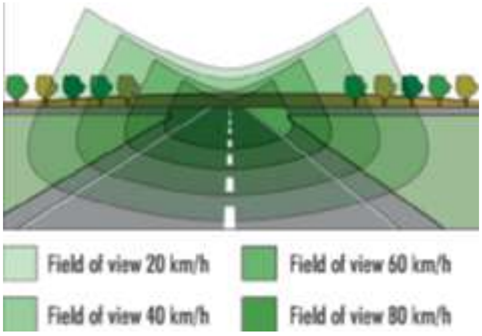
Typical accidents:

 Single vehicle accidents in a bend - going either side of the road	 At least two vehicles - different roads - turning left (right) into traffic from the right (left) side	 At least two vehicles - crossing (no turning) - different	 Pedestrian crossing street at a junction	 At least two vehicles - same direction - rear end collisions

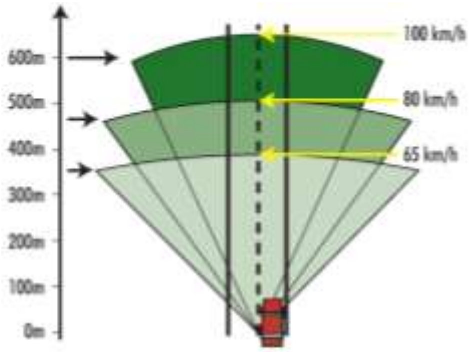
Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Reconstruction of curve, intersection, pedestrian crossings, etc. - Improved radius and visibility ($$$)	**8 – 55 %**	 Example of improved radius of horizontal curve and visibility in curve
2. Provide sufficient sight distances for adequate driver reaction - Opening of visibility (see sketch at the end of page) ($$) - Enable good orientation for drivers (e.g. adding of trees at secondary roads which clearly shows that there is intersection ahead) ($) Breaking the sightline of the driver is important to show that the road is not continuing ahead.	**20 – 38 %** **no reliable data**	 
3. Improved signing and marking - improved signing (usage of high class reflectivity materials for traffic signs, adding of chevron signs in sharp curves, using of flash beacons on approach to the pedestrian crossing, etc.) ($) - improving of markings (usage of reflective glass beads, usage of nonstandard markings, etc.) ($)	**10 – 33 %** **11 – 35 %**	

Sketches (with dimensions):



Example of speed and peripheral vision



Example of speed and focus point

Conclusion: The faster we drive the further we need to look ahead and vice versa in order to be able to read, understand and react in time to a hazard ahead.

4 INTERSECTIONS:

4.1 CHANNELIZATION OF TRAFFIC FLOWS

Problem

Channelization is a useful tool in traffic management. It should be applied to all junctions on high speed roads. This may require local widening but the small additional cost of this at the design stage will be offset by future safety benefits in almost every case. Consideration of the access needs of emergency and other priority vehicles is required, especially in the event of an accident or breakdown. If provision is not made for this, damage to kerbs will quickly occur. Channelization guides the driver through the conflict points, provides safe areas for him to stop while making a manoeuvre and reduces conflicts between different flows of traffic.

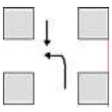
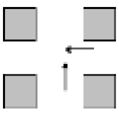
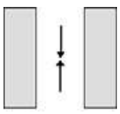
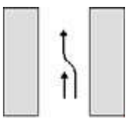
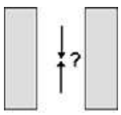
Channelization by means of road markings, raised kerbs, traffic islands and bollards, can be used to guide vehicles along a specific path on the approach to and/or exit from a junction and to position them at the safest location to make their manoeuvre. The benefits of this are that movements are simplified, less confusion arises and the number of conflict points is minimized.

Traffic islands have the added benefit of providing a refuge for pedestrians crossing the road. They also provide a convenient location for street furniture such as signs, street lighting and drainage covers. Urban channelization schemes can be relatively complex, dealing with large traffic volumes. In rural areas concern is usually focused on protecting turning vehicles from faster moving traffic and to position vehicles correctly on the road.

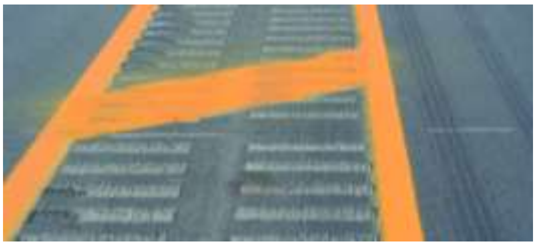
Examples of unsafe designs from TRACECA Region

 Kyrgyzstan	 Ukraine
 Moldova	 Tajikistan

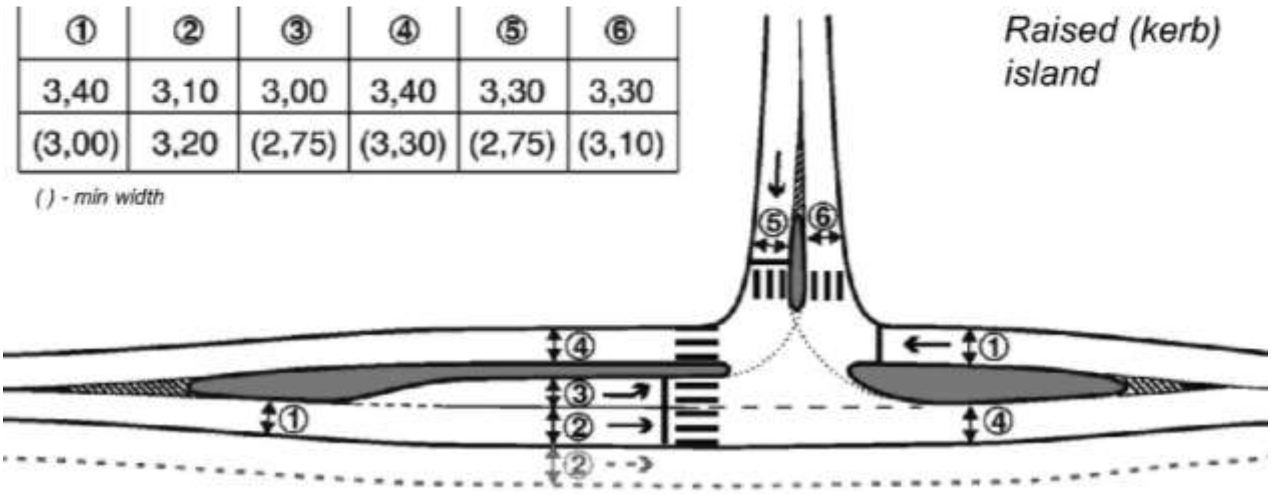
Typical accidents:

				
At least two vehicles - same road - opposite direction - turning left (right) in front of other vehicle	At least two vehicles - crossing (no turning) - different	At least two vehicles - head on collision in general	At least two vehicles - same direction - entering traffic	At least two vehicles - opposite direction no turning - others

Possible safe countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Construction of raised (kerb) islands - Local widening (if necessary) and clear guidance of driver with raised (kerb) islands ($$) - Narrowing of traffic lanes (if existing lines are too wide) ($$) - Additional lighting ($$) - sufficient length for left/right turning lane ($$)	**15 – 37 %** (full channelization at crossroads)	 Georgia
3. Usage of markings and traffic equipment - Clear marking of traffic lanes for better guiding of drivers ($) - Plastic markers, flex poles and other rubber elements can be used ($) - Advance information signs for lane direction ($)	**42 – 68 %** (full channelization at crossroads)	 Georgia
3. Usage of "ghost" island - Different texture of island surface could be used with edges on pavement level ($) - Markings and rumble strips for better guiding of drivers and unpleasant feeling crossing over the island ($) - Reflective studs for the delineation of lanes especially during night time condition ($)	No reliable data	 Example of "ghost" island with markings and rumble strips

Sketches (with dimensions):



Example of channelization of "T" junction
(Note the “protected” lane for turning traffic where it can wait in safety until a suitable gap appears to allow it to turn)

4 JUNCTIONS:

4.2 INTERSECTION TYPES ("Y" TYPE, ROUNDABOUTS, ETC.)

Problem

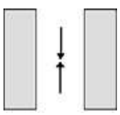
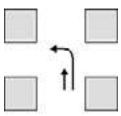
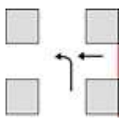
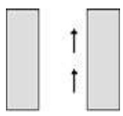
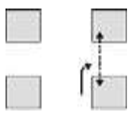
A junction is required wherever two or more roads cross, so that vehicles can pass through the junction in ways that are both safe and understandable for all road users. It is important that the junction is appropriate for the site and that it is clearly defined in terms of road priorities and legitimate manoeuvres. Common junction shapes are a T-junction, X-junction, staggered junction and cross roads. If an inappropriate junction type is used at a particular site, like "Y" type, significant safety problems can occur, including high accident rates, unnecessary delay and congestion.

The most obvious problem regarding the more widespread usage of roundabouts is the lack of familiarity of drivers with the proper use of this type of traffic control. In some of TRACECA countries roundabouts have one "Priority road", which is contrary to best international practice, where all approaching roads to roundabout should have to "Give Way" sign in order to give priority to the circulating traffic inside the roundabout. One of the road safety facts about roundabouts could be that the number of minor accidents can even increase, but the number of fatalities and serious injuries will decrease due to impact angle and reduced speeds of impact.

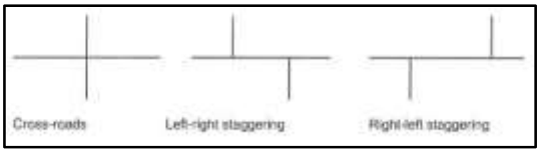
Examples of unsafe designs from TRACECA Region

 Georgia: "Y" type intersection	 Tajikistan: "Y" type intersection
 Kazakhstan: "Y" type intersection	 Azerbaijan: Huge roundabout

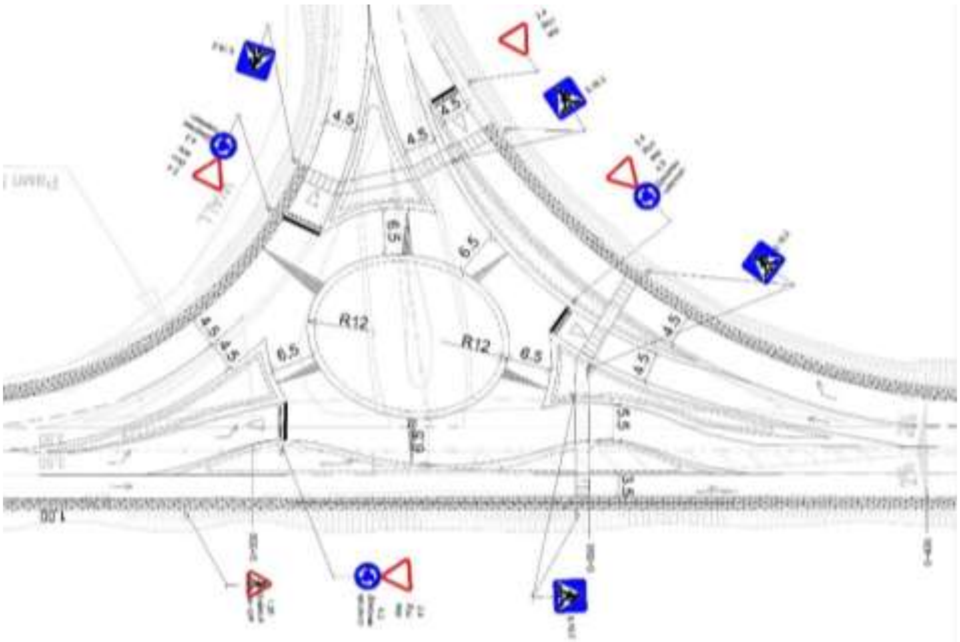
Typical accidents:

				
At least two vehicles - head on collision in general	At least two vehicles - turning or crossing - same road - same direction - turning left (right)	At least two vehicles - different roads - turning left (right) into traffic from the right (left) side	At least two vehicles - same direction - rear end collisions	Hitting pedestrian - turning right (left)

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. For “Y” type of junction: - Full reconstruction from “Y” type into “T” ($$$) - Improving of visibility ($$/$) - Improving of signing and marking ($) - Adding of rumble stripes ($) - Clear prioritization of main traffic stream by signage and markings ($) - Additional “STOP” sign for minor road appr. ($)	**20 - 70 %** **5 - 18 %** **11 - 35 %** **25 - 40 %**	
2. For cross-roads with high traffic volume on minor road approach: - Full reconstruction to staggered junctions ($$$) - Adding of traffic signals ($) - Channelization of traffic flows (narrowing of traffic lanes) ($$) - Usage of "STOP" sign on minor roads ($) - Additional traffic lanes on the minor approaches ($$)	**21 - 43%** **25 - 35%** **15 - 37%** **25 - 44%**	 Possible forms of junction staggering
3. For roundabouts - Channelization of traffic flows (narrowing of traffic lanes) ($$) - Adding of raised (curb) islands (pedestrian refuge islands and central island of the roundabout which should be shaped as a hill) to break sight lines of approaching traffic Bus bays should be at the exits behind the pedestrian crossing($$). - Usage of “Give Way” signs at all approaching legs with priority of traffic in circle ($)	**15 - 37%** **3 - 21%** **3 - 9%**	 One circle lane roundabouts are the most safe and cost effective type of junctions up to a traffic volume of 20.000 incoming vehicles per day within and outside of built up areas as well.

Sketches (with dimensions):



Example of traffic flows channelization on approaches to the roundabout
(Note how the vehicles can be positioned to safest location for manoeuvre)

4 INTERSECTIONS:

4.3 U-turns

Problem

Policies regarding the provision of gaps in medians, particularly in urban areas must balance the needs of both local and through traffic in terms of connections to local streets and enabling of U-turns. Their number should be kept to a minimum, and wherever possible overpasses/underpasses should be provided instead of allowing U turns. The main consideration which governs median opening (U-turns) is minimum turning path (that is, the length of median opening depends upon the width of median and the minimum turning path of the largest vehicle allowed on that road).

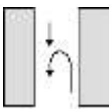
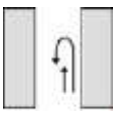
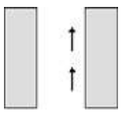
Road accidents tend to cluster at median gaps particularly on dual carriageway mainly due to the conflict between the slow manoeuvre of a wide turn and fast approaching vehicles (usually with high speed) from the other direction. This is the typical case in TRACECA countries.

There is always a conflict between serving the demands of local traffic and through traffic. The poor planning of U-turns is contrary to the interest of any wide scale area traffic control proposals for removing through traffic from the local street system. The openings are also sometimes provided at locations where due to the horizontal and vertical geometry of the road, the movements of vehicles using the facility are not clearly visible to other road users. Where local traffic dominates, the conflict between local and through traffic gets more serious. This problem is aggravated by poor design standards used for right/left turning lanes which do not offer adequate protection to the turning vehicle.

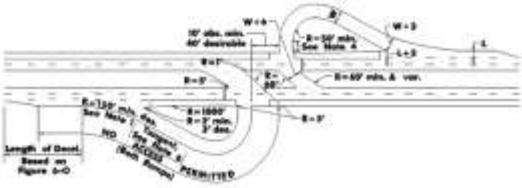
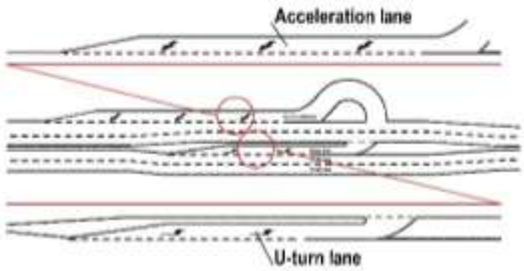
Examples of unsafe designs from TRACECA Region

 Armenia	 Azerbaijan
 Kyrgyzstan	 Moldova

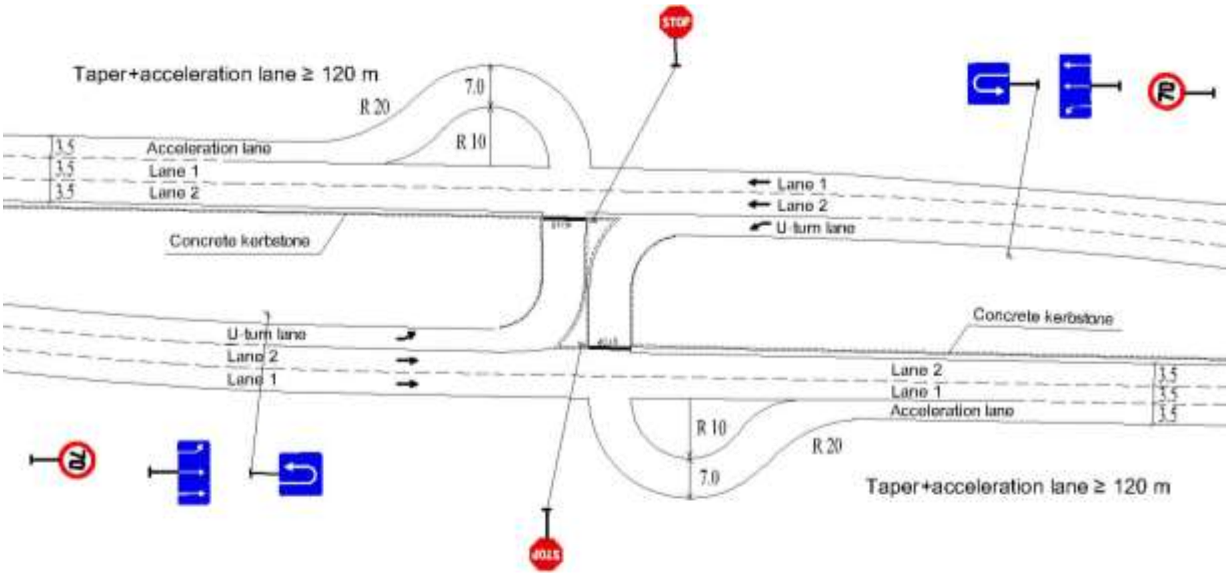
Typical accidents:

 At least two vehicles - U-turn in front of the other vehicle	 At least two vehicles - same direction - U-turn in front of the other vehicle	 At least two vehicles - same direction - rear end collisions

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Construction of "fly over" U-turns (grade separation of traffic streams) - Changing existing U-turn into safer solution with grade separation of traffic streams ($$$)	**no reliable data**	
2. Reconstruction of cross section (U-turn) - Changing existing U-turn into safer solution ($$$) - Protected deceleration lane for turning vehicle - A short crossing of opposite carriage way at right angle to minimise exposure and then an acceleration lane to join the traffic on that carriageway	**15 – 37 %**	
3. U-turn improvements (Rehabilitation) - Widening and creation of left turning lane ($$$) - Improving of U-turn radius ($$) - ITS implementation to reduce traffic speed ($$) - Additional signing and markings ($) - Where ever possible, roundabouts will offer safe U-turning manoeuvres	**4 – 27 %**	

Sketches (with dimensions):



Example of U-turn for both directions
(Note the protected lane for turning traffic to wait in safety, the short exposure when crossing and acceleration lane with hatched area to run in parallel to main stream until merging can occur).

5 PUBLIC AND PRIVATE SERVICES

5.1 SERVICES ALONG ROADSIDE

Problem

Roadside facilities (rest places and petrol stations) are necessary to serve the long distance traffic between regions and towns (villages). Drivers need to rest at least once every 2 or 3 hours in order to maintain their concentration when driving. It is useful to combine rest areas with petrol and/or service stations at 30 – 50 km distances. Entrances and exits to and from Service and Rest areas can cause a disruption to traffic on the main carriageway if they are not separated well, and special attention should be given to design and maintenance of deceleration and acceleration lanes. It is important that sufficient rest areas are provided at around 10 km intervals but not too many to avoid constant disruption of the main flow of traffic by constantly exiting and merging traffic. Such rest areas may be used for selling goods by local farmers to minimise such activity along the roads (see the example of Moldova below). Farmers should reach the areas from minor roads behind the service area.

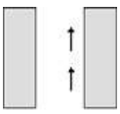
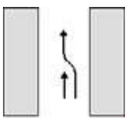
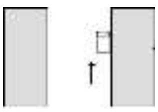
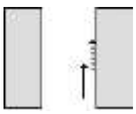
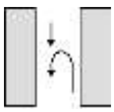
In TRACECA Region there are a lot of examples where roads are encroached upon by unacceptable commercial services or there are unsuitable rest areas. This is dangerous for all road users, because of huge speed difference and mixture of different categories of road users (sudden vehicle stops and entering the traffic, as well as presence of unprotected pedestrians on high speed roads).

Master plans, land usage, urban development and restrictions in access to the public road network are key elements for preventing these types of accidents. In good planning system these types of crashes could be prevented in early stage of planning, during Road Safety Impact Assessments (RSIA). Effective access and development controls can prevent such unsafe conditions developing.

Examples of unsafe designs from TRACECA Region

 Ukraine	 Kazakhstan
 Kyrgyzstan	 Moldova

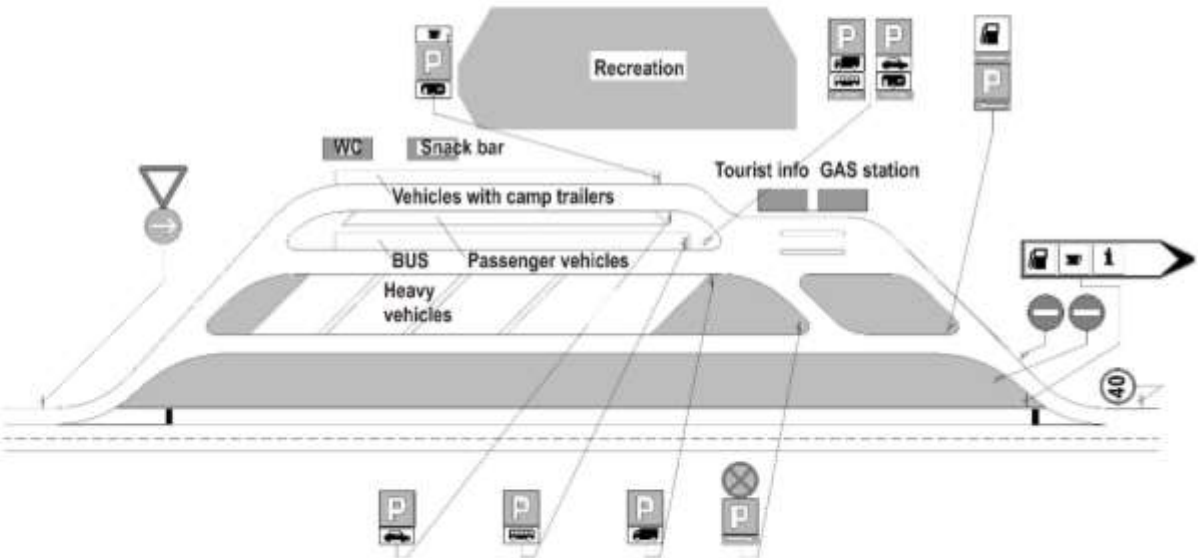
Typical accidents:

 At least two vehicles - same direction - rear end collisions	 At least two vehicles - same direction - entering traffic	 Hitting parked vehicles right (left) side of the road	 Pedestrian walking along the road	 At least two vehicles - U-turn in front of the other vehicle

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Improving of entrance/exit to services along roadside - Construction of adequate deceleration and acceleration traffic lanes ($$$-$$) - Channelization of traffic flows at entrance/exit ($$)	**15 – 37 %**	
2. Improving of parking areas - Separation from traffic ($$) - Adding and/or remarking of pedestrian walkways ($$) - Adequate position of parking with regard to objects and services ($$/$$$)	 **16 – 33 %** **10 – 32 %** **No reliable data**	
3. Improving od signing and marking of services along the roadside - Proper signing/marking (speed limit signs, directional signs, wrong way signs, parking places, pedestrian crossings, etc.) ($) - Adding of proper lighting ($$) - Additional installation of guardrails ($)	 **2 – 10 %** **25 – 74 %** **31 – 54 %**	

Sketches (with dimensions):



Example of organization of Rest area with parking and design of traffic signs

5 PUBLIC AND PRIVATE SERVICES

5.2 FACILITIES FOR PUBLIC TRANSPORT (BUS STOPS)

Problem

TRACECA Region has a diverse range of public transport modes. Economic factors can result in many of these being unsafe, but they are the only available modes of travel for the large majority of people. In such circumstances the first priorities need to be aimed at limited regulation to ensure that the safety of passengers is adequately catered for through regular roadworthiness, screening of vehicles and by having basic minimum standards for drivers and operators providing such services. Drivers are often poorly trained and educated and road accidents involving public transport vehicles are commonplace with at times, major catastrophes occurring (e.g. deaths of 11 or more persons in overloaded and unsafe mini bus).

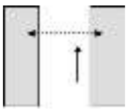
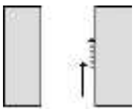
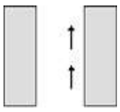
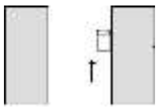
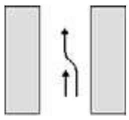
In rural areas, bus bays provided with a divider from the main carriageway are often not used by buses, which stop on the carriageway instead. This is because bus bays without dividers are used by different activities (trading, parking, etc.) which encroach into the bus bay. In urban areas such bus bays with dividers seem to operate better.

At those stops, conflict can exist between the bus and other vehicles and vulnerable road users such as pedestrians and cyclists. Usually pedestrian flows to and from Bus stops are not well catered for. Pedestrian crossings on routes to the Bus stop (say 100 m to each direction) are often inadequate.

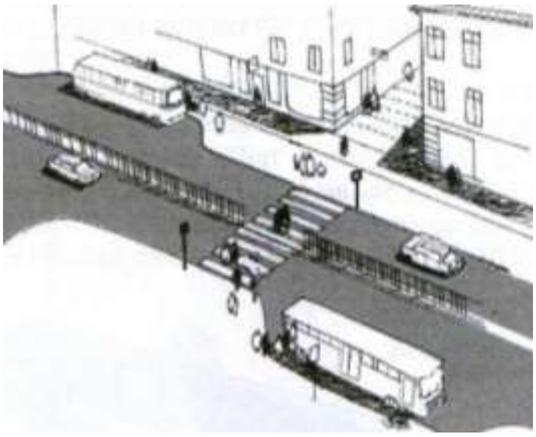
Examples of unsafe designs from TRACECA Region

 Azerbaijan	 Tajikistan
 Kazakhstan	 Ukraine

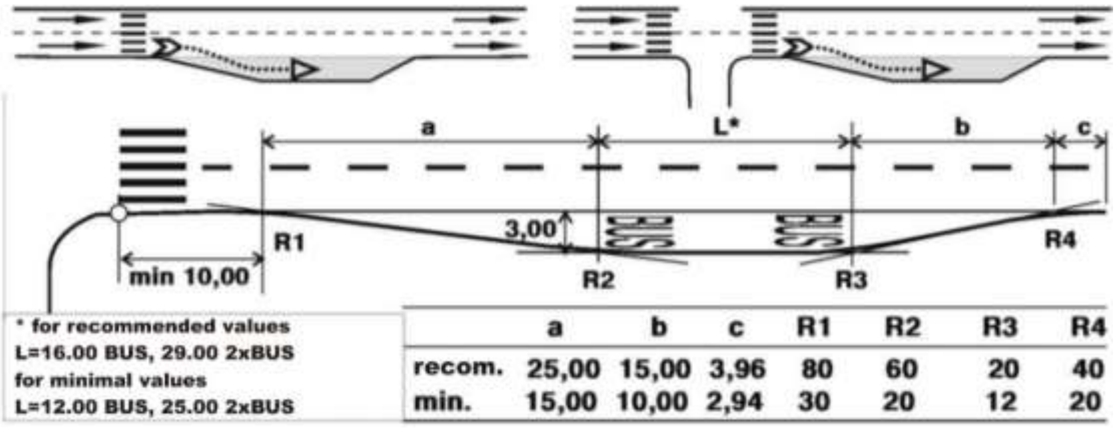
Typical accidents:

 Pedestrian crossing street outside a junction	 Pedestrian walking along the road	 At least two vehicles - same direction - rear end collisions	 Hitting parked vehicles right (left) side of the road	 At least two vehicles - same direction - entering traffic

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Removing Bus stops from main traffic flow - Separation of Bus bays from main traffic flow and connection with pedestrian crossings ($$$) - Construction of pedestrian footpath to and from Bus stops ($$/$$$) * The location of bus stops at the exits of roundabouts is very useful and safe because the speed of passing vehicles is still low.	**34 – 90 %**	 Turkmenistan
2. Improving of Bus bay within existing traffic - Traffic calming measures in zone of Bus bay ($$$-$$) - Relocation of BUS bay ($$$) Note that the pedestrian crossing is located behind the bus stop bay to reduce risks. Ideally the pedestrian crossing should be raised and there should be a safe waiting area at the centre of the road to permit pedestrians to cross in 2 movements.	**25 – 54 %** **No reliable data**	
3. Improving of signing /marking and road furniture of Bus Stops - Improved signs and marking of Bus Stop ($) - Adding of proper lighting ($$) - Additional installation of guardrails ($) - Additional installation of pedestrian fence ($) - ITS installation in Bus stop location (see example from chapter 7.1 Signing) ($$)	 **2 – 10 %** **25 – 74 %** **31 – 54 %** **No reliable data in this context**	

Sketches (with dimensions):



Recommended and minimal values for Bus bay
(Note that pedestrian crossing is behind the bus bay so passengers coming off from Bus and crossing the road can be seen by following traffic).

6 VULNERABLE ROAD USER NEEDS:

6.1 PEDESTRIAN CROSSINGS

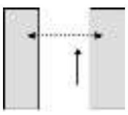
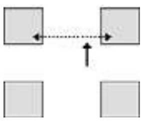
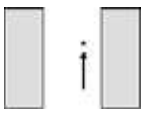
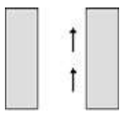
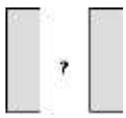
Problem

Pedestrians should not have to walk at all along interurban roads. Hard shoulders are no intended for vulnerable road users but for emergency use by vehicles only. With the exception of roundabouts, pedestrian crossings should ideally be grade separated on major roads if large numbers of vulnerable road users are expected. At-grade pedestrian crossing on dual carriageways or multi-lane roads should be forbidden unless traffic signals are provided. To enable pedestrians to cross safely crossings provided should be as underpasses or overbridges with ramps, not stairs. Any other solution significantly increases risks of with pedestrian accidents. Even though it is not in accordance with any road standards/norms in the world, including ex-soviet SNiP and GOST standards there are many such examples in TRACECA Region where pedestrian crossings are placed on the same level on an international road (see Section 1.1.)
In order to provide additional traffic capacity at junctions, local widening is sometimes carried out. This often increases the crossing distance, again creating increased risk for pedestrians.
Heavy crossing demands may sometimes occur away from junctions where vehicle speeds are very high and this is often the case in TRACECA region. The provision of underpasses or overbridges however may be too expensive and may not be well used. Designers and the road authority need to provide crossings which the pedestrians will willingly use.

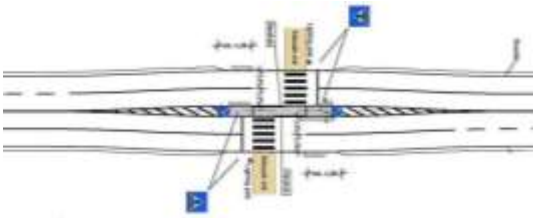
Examples of unsafe designs from TRACECA Region

 Kazakhstan	 Ukraine
 Tajikistan	 Uzbekistan

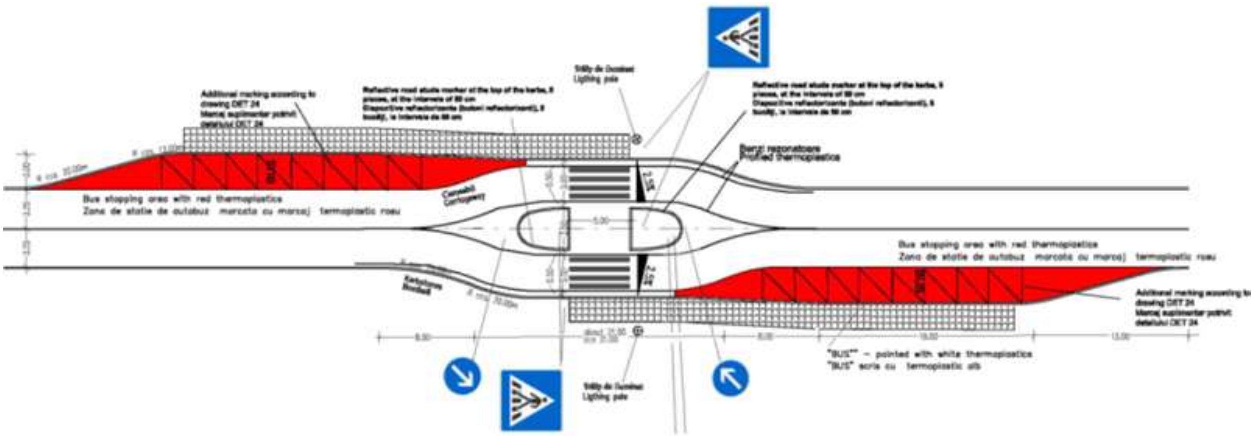
Typical accidents:

 Pedestrian crossing street outside a junction	 Pedestrian crossing street at a junction	 Pedestrian in the road	 At least two vehicles - same direction - rear end collisions	 Single vehicle accidents - others

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Separated pedestrian crossings - Construction of underpasses or overbridges - costly and efficient solution – attention should be paid to pedestrian wiliness to use ($$$) - Underpass/overbridge lighting ($$$/$$) - Installation of pedestrian guardrail in wider zone of underpass/overbridge ($$) - Motivation of pedestrians to use bridge or underpass by installing: - Different advertisements - Signage and markings - Violation recording of offenders - Good lighting - Clean, well maintained underpasses	**13 – 44 %** **9 – 32 %** **N/A** **N/A**	 Kazakhstan  Georgia * Using ramps instead of stairs encourages use by less able persons
2. Narrowing of road and usage of refuge islands - Narrowing of the traffic lanes ($$) - Installation of refuge island with fencing to redirect pedestrians to face traffic before crossing ($$) - Adding traffic lights ($) - Lighting of pedestrian crossing ($$$/$$) - Installation of pedestrian guardrail ($)	**15 – 37 %** **3 – 21 %** **2 – 12 %** **17 – 64 %** **N/A**	 (Pedestrians at Central Island can be redirected via safety fences so they face traffic before making second crossing)
3. Connecting of pedestrian paths (walking routes) with crossings - Marking of pedestrian crossing ($) - Raised pedestrian crossing ($) - School crossing patrol ($) - Adding of speed-reducing devices (humps, rumble strips, etc.) near pedestrian crossing ($)	**10 – 58 %** **35 – 67 %** **25 – 54 %**	 Georgia

Sketches (with dimensions):



Good example of pedestrian crossing and BUS stops

6 VULNERABLE ROAD USER NEEDS:

6.2 FOOTPATHS AND FOOTWAYS

Problem

Pedestrian accidents contribute a substantial proportion of road accident deaths and injuries. Pedestrians are particularly at risk in urban surroundings. In TRACECA countries and can typically contribute to 50% of deaths. Roads are usually designed with raised pedestrian footways as part of the cross-section but on interurban roads, footways are rarely provided, although in some locations, pedestrian flows may be very high.

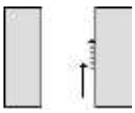
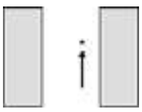
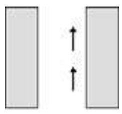
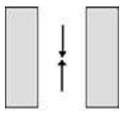
Footways have great implications for safety and every effort should be made to segregate pedestrians and vehicles where space allows. Separate routes make travel much safer for vulnerable road users. Special care must be taken to ensure that footways do not become obstructed, especially by street traders and/or parked vehicles, that the surfaces are easy to walk on and that they provide a continuous route.

Substantial conflict problems usually exist where roads pass through rural settlements as the main road traffic travelling very fast often passes very close to the existing buildings leaving no footpaths for pedestrians and increased risk and danger for pedestrians.

Examples of unsafe designs from TRACECA Region

 Kazakhstan	 Georgia
 Ukraine	 Tajikistan

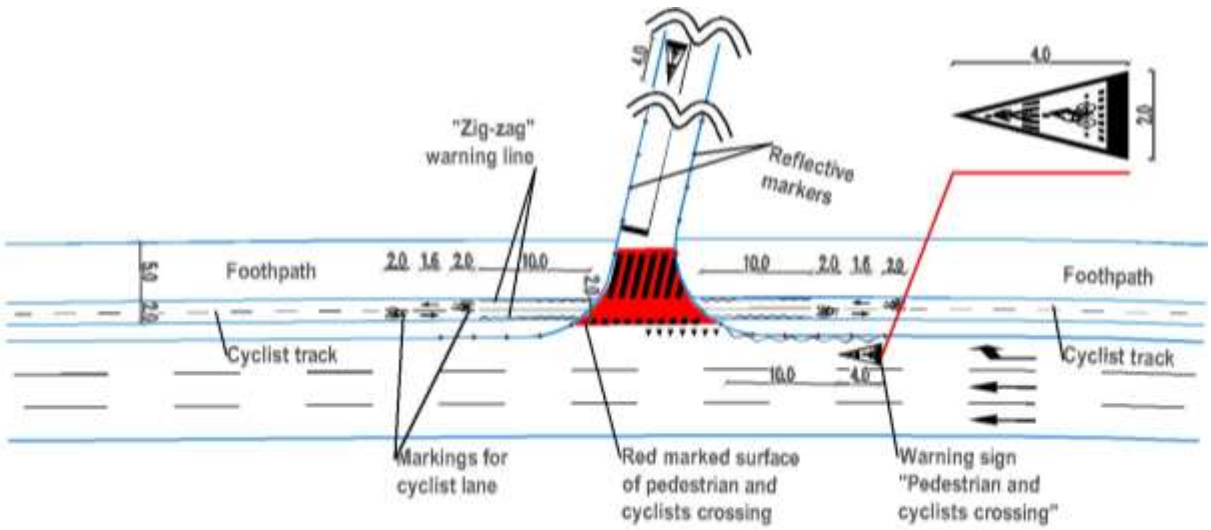
Typical accidents:

				
Pedestrian walking along the road	Pedestrian in the road	Pedestrians on pavement or bicycle lane	At least two vehicles - same direction - rear end collisions	At least two vehicles - head on collision in general

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Separation of motorised traffic and vulnerable road users wherever possible - Construction of separated pedestrian footways and cyclist tracks ($$$) - Building of footpaths and cyclist lanes/tracks where road passes through urban areas ($$$) - Building of wider hard shoulder outside urban areas ($$)	 **35 – 67 %** **10 – 32 %** **21 – 32 %**	 Ukraine
2. Time separation - Installation of traffic lights where footpaths (footways) and cyclist tracks/lanes cross the road ($$)	**2 – 12 %**	
3. Good signing and marking of urban and rural footpaths, footways and cyclist tracks/lanes ($) - speed limitation for vehicles ($$) - access control for specific vehicles category ($)	**2 – 10 %**	

Sketches (with dimensions):



Example of marking of footpaths and cyclist tracks on crossing of the road

7 TRAFFIC SIGNING, MARKING AND LIGHTING:

7.1 SIGNING

Problem

Warning signs and warning markings are used to give advance notice of a potential hazard ahead or of any unexpected feature of the road geometry. The signs are used in specific situations when there is a change in the road, such as in a bend, on high speed road or on the approach to junction. The location of signs is very important because they should provide adequate warning or information at sufficient distance, however they should not obscure important road features. Of great importance for the visibility of the signs is that they be located in positions where overgrown vegetation cannot obscure the visibility of the sign. Signs must be visible at all times, so reflective materials should be used for night-time visibility and urban signs may require to be lit internally or externally. In TRACECA Region, it is common practice for the signs to be missing (even at dangerous locations), not properly positioned, without reflectivity, non-standardized or even not uniform to International UN Conventions.

A recurring problem with signs is of them being obscured, either by permanent features such as street furniture and vegetation or by parked vehicles and, on dual carriageways, by moving vehicles in the nearside lane (if there is no repeated sign on the other side of the road). Too many signs can detract from their objective by overloading the driver with too much information too quickly, which leads to confusion or to a situation where the driver ignores certain signs. Signs may not be visible at night time because of poor illumination, lack of routine maintenance, continuity of power supply or inappropriate positioning (too high, set back out of road or turned away from driver). If reflective signs are not regularly cleaned, they may not retain their design properties.

Examples of unsafe designs from TRACECA Region

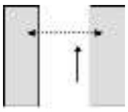
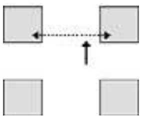
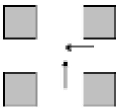
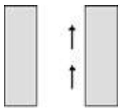
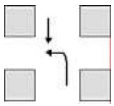
Tajikistan

Georgia

Kazakhstan

Kyrgyzstan

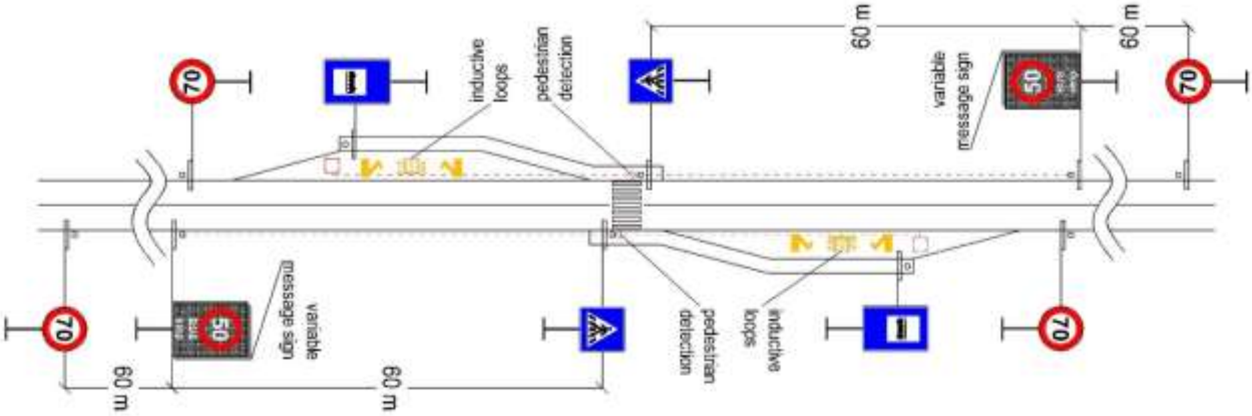
Typical accidents:

				
Pedestrian crossing street outside a junction	Pedestrian crossing street at a junction	At least two vehicles - crossing (no turning) - different	At least two vehicles - same direction - rear end collisions	At least two vehicles - same road - opposite direction - turning left (right)

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Usage of high class of reflectivity materials for traffic signs - usage of higher class of reflectivity materials for signs on motorways and highways (roads with higher speed limit) ($) - usage of higher class of reflectivity materials for traffic signs “Yield at entry”, “Stop”, “Pedestrian crossing”, etc. ($) - yellow-green border usage for highlighting of signs on dangerous places ($)	**10 – 33 %**	 Chevrons in curves should be with yellow and red arrows instead of white/red or white/black
2. Variable message signs (VMS) usage - accident warning signs ($$) - fog warning signs ($$) - queue warning signs on motorways ($$) - Average over speeding control signs ($$) - Information signs of average violations at pedestrian crossings ($$)	 **22 – 59 %** **63 – 93 %** **4 – 26 %** **24 – 62 %** **65 – 96 %**	
3. Maintenance of traffic signs - Traffic sings maintenance ($) - Displacement of traffic signs ($) - Removal and replacement of traffic signs ($) - Visibility of colours in traffic signing, Yellow – red chevrons are earlier detected than red-white (Black-white are even worse) ($)	**7 – 15 %**	

Sketches (with dimensions):



Example of usage of VMS for speed limit in accordance with BUS stop detection and pedestrian crossing detection

7 TRAFFIC SIGNING, MARKING AND LIGHTING:

7.2 ROAD MARKINGS

Problem

Road markings play a very important role in guiding the driver and providing him with the information necessary to negotiate conflict points on the road network and should be of high priority for those seeking to improve road safety. Appropriate information should be given to the driver through the use of different types and colors of road marking. Stop and give-way lines at junctions help to position the driver on the road to minimize his risk. Center lines can be used to indicate locations where overtaking is dangerous while edge lines give advance warning of changes in alignment and if corrugated can be used as warning of drifting towards shoulder. Where possible, high quality paint containing small glass beads (for reflectivity at night) should be used. Centre and edge lining reinforced through the use of studs or vibrolines (corrugated) to provide rumble warning are strongly recommended.

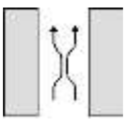
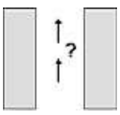
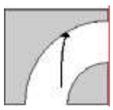
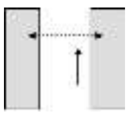
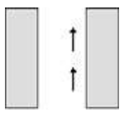
Although most of TRACECA countries have their own national standards for road marking, many of the roads do not have good markings (without reflectivity and/or are partially missing). This is partly due to the fact that road marking paint available locally often tends to be of poor quality whilst imported road marking paint is often considered to be too expensive (although it lasts longer, reduces risk of accidents).

The poor conditions of roads (potholes, deformations, etc.) can also make road marking difficult to apply in any effective manner. Shortage of special machinery, skilled/trained technicians and the cost of imported thermoplastics makes problems in implementation of thermoplastic lines in TRACECA Region.

Examples of unsafe designs from TRACECA Region

 Kazakhstan	 Tajikistan
 Uzbekistan	 Moldova

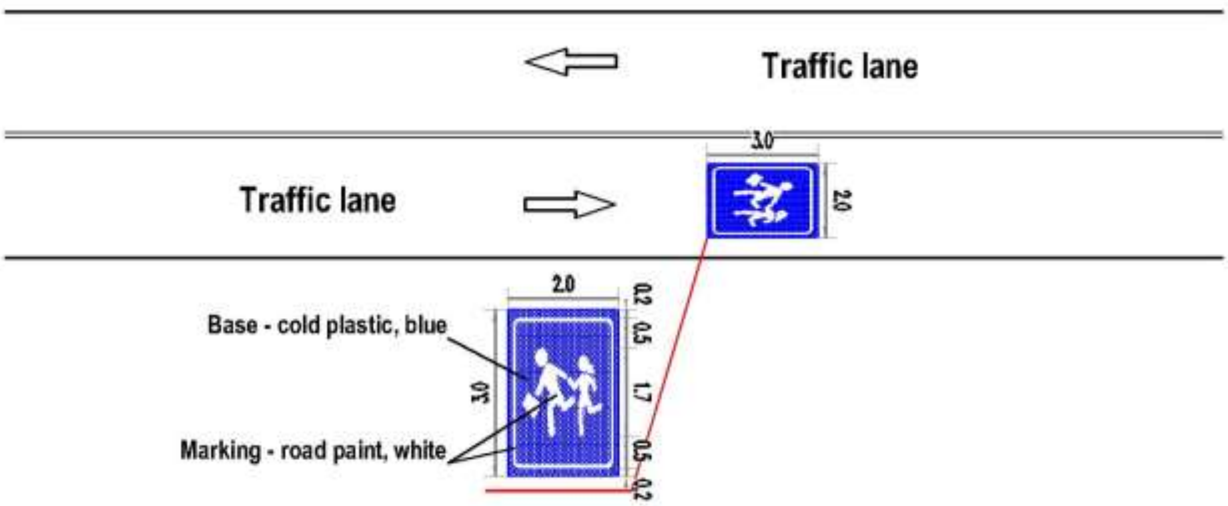
Typical accidents:

				
At least two vehicles - same direction - side collision	At least two vehicles - same direction - others	Single vehicle accidents in a bend - going either side of the road	Pedestrian crossing street outside a junction	At least two vehicles - same direction - rear end collisions

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasures with (EC)	AR	Illustrations
1. Improved road markings: - Reflective glass beads for road markings ($) - Durable road marking materials (cold plastic, thermoplastic, fabricated tapes) ($$/$) - Delineators ($) - Reflective road markers / studs ($) - Rumble strips, edge rib-lines, reflective road studs, etc. ($) - Non-standard markings for school zones, dangerous locations, etc. ($) - Marking of traffic signs on pavement ($) - Different colours of road markings (for highlighting of standard elements of road markings) ($) - Different pavement colour ($)	**2 – 7 %** **8 – 21 %** **17 – 45 %**	 
3. Maintenance of road markings - Remarking ($) - Cleaning of markings ($)	**No reliable data**	

Sketches (with dimensions):



Example of road marking of traffic sign for school zone

7 TRAFFIC SIGNING, MARKING AND LIGHTING:

7.3 LIGHTING

Problem

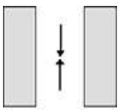
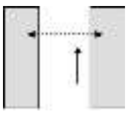
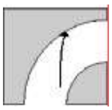
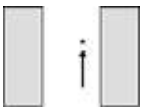
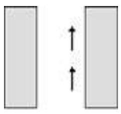
Night-time accidents on roads passing through urban areas or on streets in urban areas can be substantially reduced by the implementation of adequate road/street lighting. It is particularly important where there are high proportions of pedestrians, cyclists or other poorly lit road users, including animals. Lighting should provide a uniformly lit road surface in order to provide visibility of all road users (vehicles and pedestrians) and not to hide them in shadow. The design of the lighting system should be designed to the road surface reflection characteristics in order to provide the optimum quality and quantity of illumination. Light coloured surfaces give better silhouette vision than the dark ones. If only limited funds are available, efforts should be made to provide lighting on at least the most important routes and on dangerous locations along such routes such as intersections and pedestrian crossings involving large movement of pedestrians.

Lighting is expensive to install and maintain, but usage of cheaper LED lighting and solar power lighting system can reduce costs in future years. However, without proper maintenance, the resulting inconsistency in lighting can itself be a safety hazard. Maintenance could be a problem in some of TRACECA countries, because of inadequacy of the allocated funds. Careful attention needs to be paid to the siting of lamp posts as they can be hazardous for an errant vehicle and if possible frangible posts should be used. The column can be a significant visual obstruction at critical locations.

Examples of unsafe designs from TRACECA Region

 Kazakhstan	 Azerbaijan
 Uzbekistan	 Tajikistan

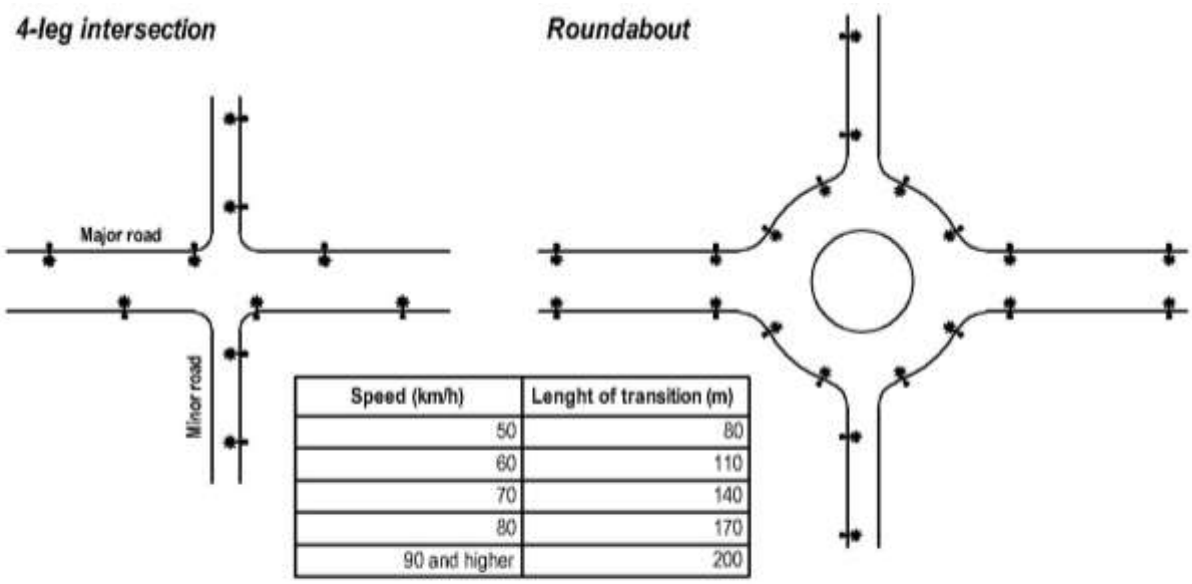
Typical accidents:

				
At least two vehicles - head on collision in general	Pedestrian crossing street outside a junction	Single vehicle accidents in a bend - going either side of the road	Pedestrian in the road	At least two vehicles - same direction - rear end collisions

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Adding of lighting where needed ($$$)	**25 – 74 %**	 Turkmenistan
2. Evenness of illumination (improving of existing lighting quality) ($$) - Usage of solar power and LED for energy saving system	**8 – 20 % (for up to double)** **25 – 79 % (for up to 5 times)**	 Azerbaijan
3. Maintenance of lighting - Changing of lamps/LED ($) - Cleaning of lamps/LED/solar panels ($) - Installation of guardrails for protection of lamps from traffic and vice versa ($$)	**No reliable data**	 Uzbekistan

Sketches (with dimensions):



Speed (km/h)	Lenght of transition (m)
50	80
60	110
70	140
80	170
90 and higher	200

Example of lamp placement on 4-leg intersection and roundabout with recommended length of transition zone from lighted section to unlighted one for different speeds ("tunnel effect")

8 ROADSIDE FEATURES AND PASSIVE SAFETY INSTALLATIONS

8.1 ROADSIDE OBSTACLES (PLANTS, TREES, LIGHT POLES, ADVERTISEMENTS, ETC.)

Problem

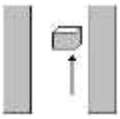
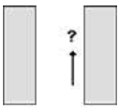
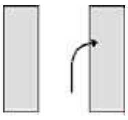
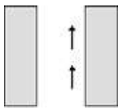
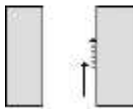
The presence of roadside obstacles, street furniture (for example, road signs and lighting columns) advertising signs and trees has two safety implications. The first is the potential danger of collision, and the second is their obstruction of visibility. Visibility is important not only for the driver, but also to other road users. Obstructions caused by trees, for example, may result in a pedestrian making an unwise decision.

Great care should be taken concerning the positioning of roadside features which may either obstruct visibility, lead to accidents or increase accident severity. Where obstructions cannot be practically removed, and contribute to hazardous situations, consideration should be given to their replacement with equipment designed to collapse on impact, re-alignment of the road, or the introduction of barriers. Once a road is completed, care must be taken to ensure that obstacles are not introduced by other institutions subsequently, such as telephone or electricity authorities. Vegetation should be trimmed regularly and planning controls should be enforced to prevent stalls and structures being too close to the road edge. In some TRACECA countries, trees are often planted adjacent to roads in order to provide shade for pedestrians, animals and parked vehicles and in other countries to prevent the wind from bringing snow onto the road.

Examples of unsafe designs from TRACECA Region

 Uzbekistan	 Tajikistan
 Azerbaijan	 Kyrgyzstan

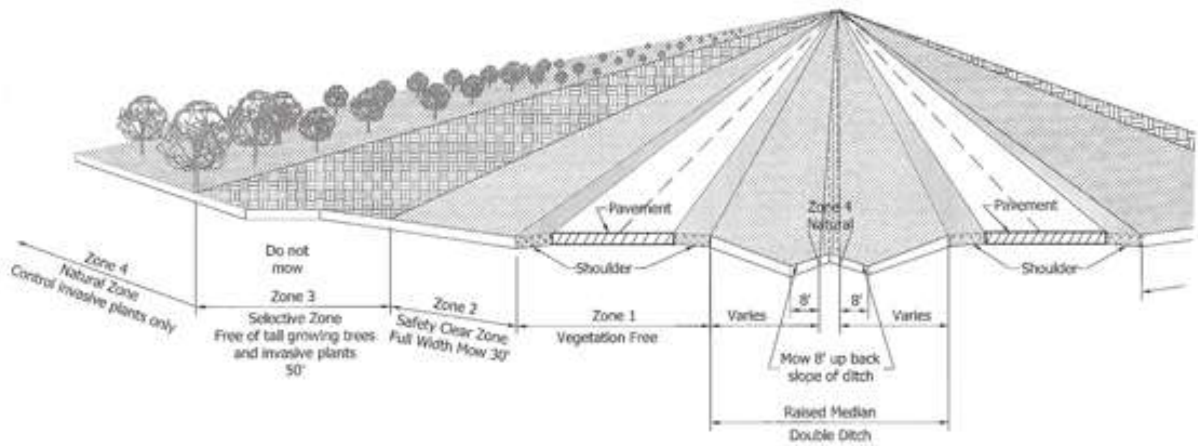
Typical accidents:

				
Single vehicle accidents with obstacles on or above the road	Single vehicle accidents with obstacles - others	Single vehicle accident - Leaving straight road - either side of the road	At least two vehicles - same direction - rear end collisions	Pedestrian walking along the road

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Removing roadside objects from road to create a “clear zone” without potential obstacles - Removing of hard (un-deformable) roadside objects from clear zone ($$$/$$) - Relocation of road layout ($$$)	 **43 – 46 %** **No reliable data**	
2. Relocation of hard roadside objects - Relocation of hard objects out of clear zone (on safe distance) ($$$-$$) - Providing better visibility in clear zone – traffic mirrors, ITS, etc. ($$) Note: There have to be obstacle free zones of 9 m for speed limits of 100 km/h, 6 m for 80 km/h and 3 m for 60 km/h	 **20 – 24 %** **20 – 38 %**	
3. Alter to reduce severity or protect roadside hazards - Frangible lighting/sign/etc. poles ($) - Grade steep slopes, 4:1 or flatter ($$) - Safe culverts ($) - Installation of guardrails ($$$-$$) - Marking of roadside object to make them more visible (usage of reflective signs, etc.) ($) - Marking edge lines in form of rumble strips ($)	 **25 – 72 %** **38 – 46 %** **No reliable data** **41 – 52 %** **11 – 45 %** **2 – 20 %**	 Barrier around/in front of a tree

Sketches (with dimensions):



Example of vegetation management in cross section of highway

8 ROADSIDE FEATURES AND PASSIVE SAFETY INSTALLATIONS:

8.2 GUARDRAILS

Problem

Many accidents on high speed roads involve vehicles leaving the road and colliding with hazardous obstacles such as trees, bridge supports or simply rolling over down a high embankment. Similarly, a vehicle running off onto the lane in the opposite direction of a dual carriageway runs the risk of collision with an oncoming vehicle and like hood of death or serious injury for vehicle head on occupants.

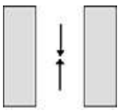
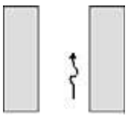
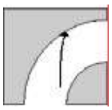
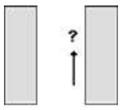
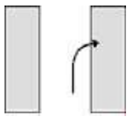
The risk of these types of accidents can be significantly reduced by the use of guard rails or barriers. The purpose of the barrier is to absorb the impact with as little overall severity as possible and to keep the vehicle contained in its carriageway. Barriers and safety fences may also be introduced to protect roadside facilities from errant vehicle impact.

The correct design of safety fences and barriers is important to prevent accidents which otherwise can often be very severe. They should be designed to absorb kinetic energy with as little risk of injury to vehicle occupants as possible. Concrete blocks have to be connected by steel armatures like a strong chain, otherwise themselves they are dangerous obstacles. They are intended to be placed between the carriageway and the objects which cause severe accidents if hit, such as bridge abutment. They are also used to retain vehicles on high embankments or mountain roads. Their use on high speed roads is justified, but care needs to be taken concerning details, particularly at the start and end points and minimum barrier length in order to work safely. Damaged barriers must be repaired immediately as they can cause serious damage if hit by passing vehicles and if they are not in their designed condition.

Examples of unsafe designs from TRACECA Region

 Uzbekistan	 Georgia
 Azerbaijan	 Kazakhstan

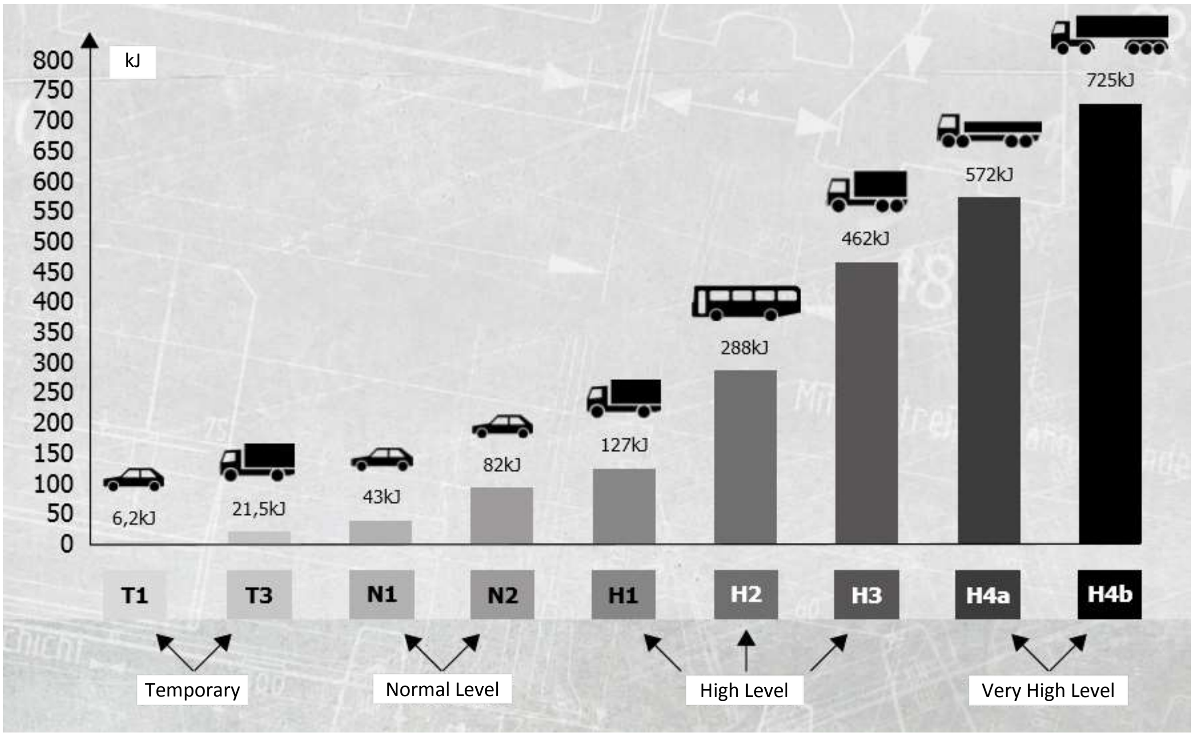
Typical accidents:

 At least two vehicles - head on collision in general	 Single vehicle accidents on the road	 Single vehicle accidents in a curve - going either side of the road	 Single vehicle accidents with obstacles - others	 Single vehicle accident - Leaving straight road - either side of the road

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Adding right type of guardrails when missing - Adding missing guardrails ($$$-$$) - Installation of proper barrier type ($$$) - Adding barriers connection elements ($)	**31 – 54 %**	 Albania
2. Improving of existing guardrail system - Closing of "open windows" ($$-$) - Adding transition elements between two different types of barriers ($$) - Using of appropriate beginning/end elements - guardrail extension in front of dangerous point ($$) - Smoother slopes ($$)	**20 – 42 %**	 

Sketches (with dimensions):



The norm EN 1317 Containment Level

9 TEMPORARY SIGNING AND MARKING AT WORK ZONES

Problem

A work zone is an area of road or roadside where construction, maintenance or other works are performed and which may affect the safety and limit the free movement of road users through and in the vicinity of the Work Zone. Work zones are zones on the road with higher risk of accidents for both road users (vehicle occupants and vulnerable categories) and workers. A Traffic Management Plan (TMP) of good quality should be made and followed so that all participants in traffic are protected against risk of a traffic accident. Such TMP should contain all elements starting from design, placement, maintenance to the removal of all elements regulating the road traffic.

To minimize the problems and increase safety, work zone layout (marking and signing) requires special consideration for the following reasons:

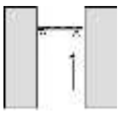
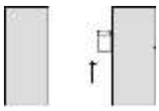
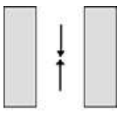
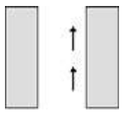
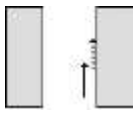
- Work zone is a section of road where, most often, geometrical characteristics of the road and the traffic conditions are changed to poorer conditions (less safe). The types of executed works are often road construction, rehabilitation and maintenance, but there are other types of work on the road that need the same treatment, for instance work with cables, pipes etc. located in the road area.
- Employees in work zones spend most of their working hours directly exposed to traffic. In accidents, happening in work zones, these employees are often the victims, and often at as much at risk as the road users.

The growing international transit traffic flow in TRACECA countries implies the need for main traffic corridors to be constructed according to international standards and requires European standards and a widely recognized and consistent system for road works signing and work zone safety.

Examples of unsafe designs from TRACECA Region

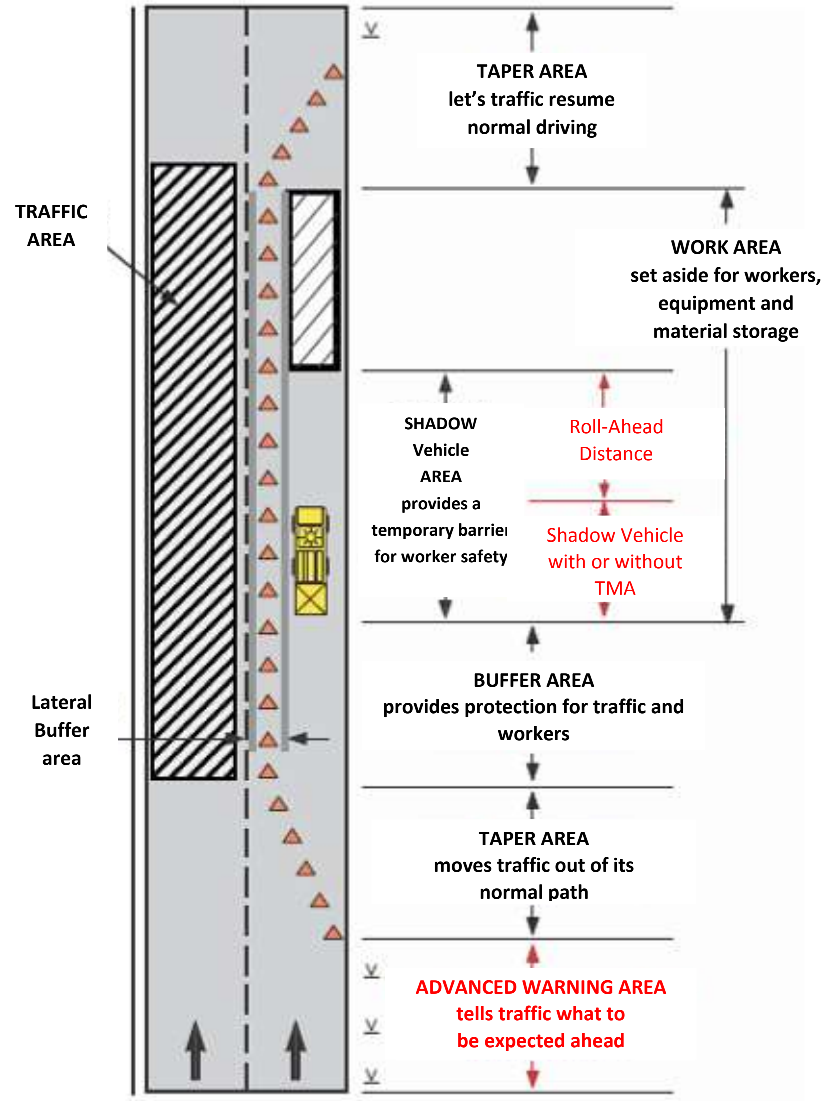
 Armenia	 Ukraine
 Kazakhstan	 Azerbaijan

Typical accidents:

 Single vehicle accidents with roadwork materials	 Hitting parked vehicles right (left) side of the road	 At least two vehicles - head on collision in general	 At least two vehicles - same direction - rear end collisions	 Pedestrian walking along the road

Possible countermeasures with expected costs (EC) and accident reductions (AR):

Countermeasure with (EC)	AR	Illustrations
1. Establishing regular (best practice) of working zone, the road markings in working areas should be in yellow ($$$-$$)	5 – 65 % (for traffic accidents in work zones)	



Sketches (with dimensions):

Speed limit (km/h)	Minimum buffer area (m)	
	Lateral	Longitudinal
40	0.5	30
50	0.5	35
60	0.5	40
80	0.5	60
100	1.0	100
120	1.0	100

Recommended dimensions of lateral and longitudinal buffer areas in work zones

10 ACCIDENT TYPE SKETCHES

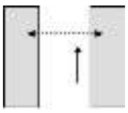
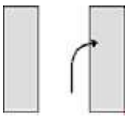
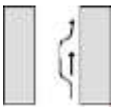
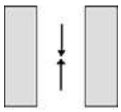
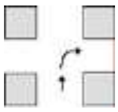
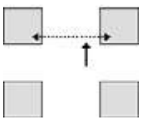
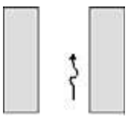
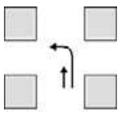
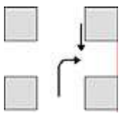
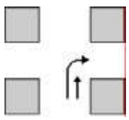
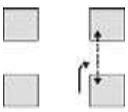
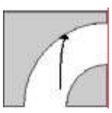
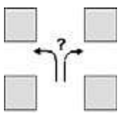
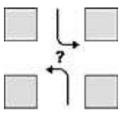
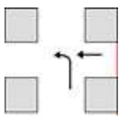
BASIC OF COMMON ACCIDENT DATA SET (CADaS)

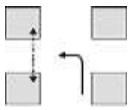
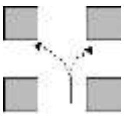
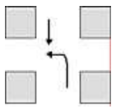
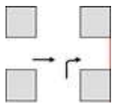
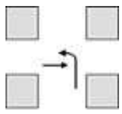
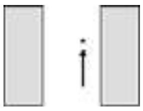
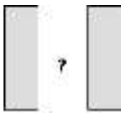
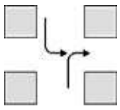
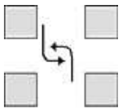
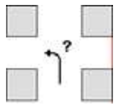
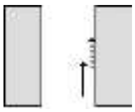
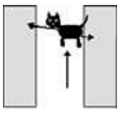
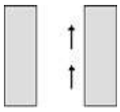
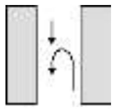
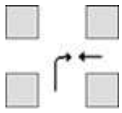
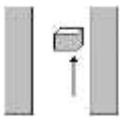
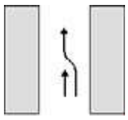
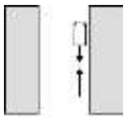
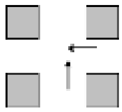
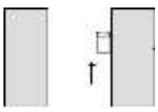
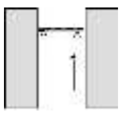
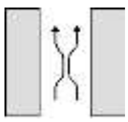
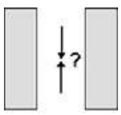
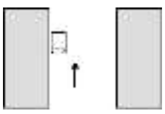
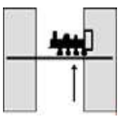
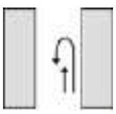
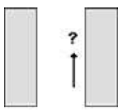
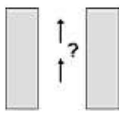
Introduction

European Union countries have a long history in collecting accident data via different national collection systems. At European level, road accident data are also available since 1991 in disaggregate level in CARE (Community database on road accidents resulting in death or injury). The purpose of CARE system is to provide a powerful tool which would make it possible to identify and quantify road safety problems throughout the European roads, evaluate the efficiency of road safety measures, determine the relevance of Community actions and facilitate the exchange of experience in this field. It also allows countries to benchmark themselves against other countries to assess areas where they need to do more.

Due to differences in accident data collecting between EU countries, new recommendations have been agreed for a Common Accident Data Set (CADaS) consisting of a minimum set of standardized data elements, which will allow comparable road accident data to be available throughout Europe. In this way, more variables and values with a common definition will be added to those already contained in the previous models of the CARE database. They will maximize the potential of CARE database allowing more detailed and reliable analyses at European level.

Common Accident Type Sketches

Pedestrian crossing street outside a junction 	Single vehicle accident - Leaving straight road - either side of the road 	At least two vehicles - same direction - overtaking 	At least two vehicles - head on collision in general 	At least two vehicles - turning or crossing - same road - same direction - rear end collision 
Pedestrian crossing street at a junction 	Single vehicle accidents on the road 	At least two vehicles - turning or crossing - same road - same direction - turning left (right) 	At least two vehicles - same road - opposite direction - turning right (left) in front of other vehicle 	At least two vehicles - turning or crossing - same road - same direction - turning right (left) 
Hitting pedestrian - turning right (left) 	Single vehicle accidents in a bend - going either side of the road 	At least two vehicles - turning or crossing - same road - same direction - others 	At least two vehicles - same road - opposite direction - turning others 	At least two vehicles - different roads - turning left (right) into traffic from the right (left) side 

Hitting pedestrian - turning left (right) 	Single vehicle accidents In junctions or entrances 	At least two vehicles - same road - opposite direction - turning left (right) in front of other vehicle 	At least two vehicles - different roads - turning right (left) in front of vehicle from the left (right) 	At least two vehicles - different roads - turning left (right) into traffic from the left (right) side 
Pedestrian in the road 	Single vehicle accidents - others 	At least two vehicles - same road - opposite direction - turning into same road 	At least two vehicles - same road - opposite direction - turning into opposite roads 	At least two vehicles - different roads - turning into traffic - others 
Pedestrian walking along the road 	Single vehicle accidents with animals 	At least two vehicles - same direction - rear end collisions 	At least two vehicles - U-turn in front of other vehicle 	At least two vehicles - different roads - turning right (left) - head on collision 
Pedestrians on pavement or bicycle lane 	Single vehicle accidents with obstacles on or above the road 	At least two vehicles - same direction - entering traffic 	At least two vehicles - opposite direction no turning - reversing 	At least two vehicles - crossing (no turning) - different 
Hitting parked vehicles right (left) side of the road 	Single vehicle accidents with roadwork materials 	At least two vehicles - same direction - side collision 	At least two vehicles - opposite direction no turning - others 	
Hitting parked vehicles left (right) side of the road 	Accidents between train and vehicle 	At least two vehicles - same direction - U-turn in front of other vehicle 	Single vehicle accidents with obstacles - others 	At least two vehicles - same direction - others 

Examples of real accidents from TRACECA Region and respective accidents and its sketches

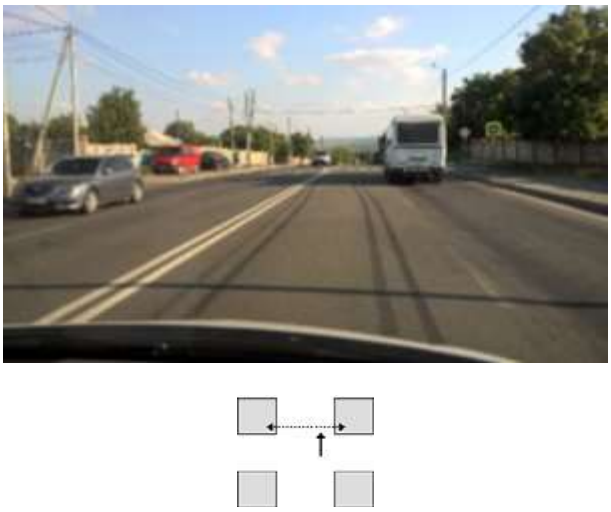
Armenia

Kyrgyzstan

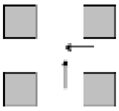
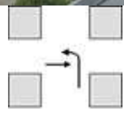
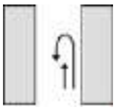
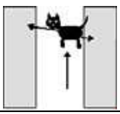
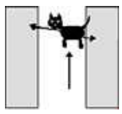
Kazakhstan

Ukraine

Moldova



Azerbaijan

Kyrgyzstan  	Uzbekistan  
Moldova  	Kazakhstan  na
Kazakhstan 	Kazakhstan 
	

11 POTENTIAL CRASH REDUCTION FROM COUNTERMEASURES/TREATMENTS

Introduction

For any kind of countermeasure proposal, it is necessary to know the crash reduction potential. Therefore, a list is proposed of the most usual low cost countermeasures with their expected effects.

The following table is collated from results of different international research projects and case studies and can be used for understanding the potential crash savings after implementation of different countermeasures.

Table 11.1 presents each different proposed countermeasure (treatment) and its range potential crash reduction effects as a percentage. (Usually, minimum and maximum effects are presented).

Table 11.1: Efficiency (crash reduction) of different countermeasures

Treatment	Potential crash reduction [%] (different sources/research)
Road Standard	
Improve to higher standard	19-33
Increase number of lanes	22-32
Lane widening 0,3 – 0,6 m	5-12
Paved shoulder widening 0,3 - 1 m	4-12
Add median strip	40
Bridge widened or modified	25
Widen shoulder	10
Overtaking lane	20
Right turn lane	40
Left turn lane	15
Pedestrian overpass	10
Side slope flattening from: 2:1	
to 4:1 ... 7:1 or flatter	6 ... 15
Side slope flattening from: 4:1	
to 5:1 ... 7:1 or flatter	3 ... 11
Service roads	20-40
Traffic calming	12-60
Speed reduction from 70 km/h to 50 km/h	10-30
Speed reduction from 90 km/h to 60 km/h	17-40
Horizontal Alignment	
Improve geometry	20-80
Curvature: improving radius	33-50
Vertical Alignment	
Gradient / removing crest	12-56
Super elevation improvement/introduction	50
Passing lane	11-43
Climbing lane	10-40
Road Structure	
Lane widening	12-47
Skid resistance improvement	18-74
Shoulder widening	10-40

Shoulder sealed	22-50
Road verge widening	13-44
Junction Design	
Staggered (from straight) crossroads	40-95
T-junctions (from Y-junctions)	15-50
Fully controlled right turn phase	45
Roundabouts (from uncontrolled)	25-81
Roundabouts (from traffic signals)	25-50
Mini roundabouts (from uncontrolled)	40-47
Turning lanes	10-60
Traffic islands	39
Sheltered turn lanes (urban)	30
Sheltered turn lanes (rural)	45
Additional lane at intersection	20
Skid resistant overlay	20
Red light camera	10
Law enforcement by the Police	7-25
Traffic Control	
Regulatory signs at junctions	22-48
Guidance/directional signs at junction	14-58
Overhead lane signs	15
Side road signs	19-24
Brighter signs and markings	24-92
Signs and delineation	29-37
Bend warning signs	20-57
Stop ahead sign	47
Speed advisory sign	23-36
Warning/advisory signs	20
Speed limit lowering - & sign	16-19
Yield/Give Way	59-80
Stop sign	33-90
Signals from uncontrolled	15-32
Signals - modified	13-85
Junction channelization	10-51
Remove parking from road side	10-25
Visibility	
Lane markings	14-19
Edge markings	8-35
Yellow bar markings	24-52
Raised reflective pavement marking	6-18
Delineator posts	2-47
Flashing beacons	5-75
Lighting installations	6-75
Sightline distance improvement	28
Channelization medians	22-50
Crash Amelioration	
Median barrier	14-27
Side barriers	15-60

Frangible signs	30
Tree removal (rural)	10
Pole removal (lighting poles, urban)	20
Embankment treatment	40
Guardrail for bridge end post	20
Impact absorber	20
Pedestrian Facilities	
Pedestrian walkways	33-44
Pedestrian zebra crossings	13-34
Raised zebra crossings	5-50
Pelican crossings	21-83
Marking at zebra crossing	-5-14
Pedestrian refuges	56-87
Footbridges	39-90
Pedestrian fencing	10-35
Cycling Facilities	
Cycle schemes	33-56
Marked cycle crossing at signals	10-15
Cyclist advanced stop line at junctions	35
Rail Crossings	
Flashing signals	73-91
Automatic gates	81-93
Traffic Calming	
30 km/h zones (inc. humps, chicanes etc.)	10-80
Rumble Strips	27-50
Rumble Strips and Bumps	20-80

NOTES:

1. Crash Reductions are NOT ADDITIVE, use highest value if multiple treatments are proposed for a particular location.
2. Reductions apply to all crashes within single intersections or single midblock that contain the treatment.

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13 AUTHOR PEN PORTRAITS

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Dr Alan Ross has 4 degrees (in civil engineering, Traffic engineering, Management Sciences (traffic police enforcement) and Road Safety Action Plans) and over 35 years of experience. He has wide experience in assessing Road Safety needs and in development of Road Safety Strategies, Action Plans and projects. He is a recognized leading international expert on Road Safety issues and has advised Aid agencies, development banks, EU and governments in benchmarking and in the design, implementation and monitoring of Road Safety Strategies, Action plans and initiatives in all sectors in around **60 countries around the world**. He helped establish the Global Road Safety Partnership (GRSP) and assisted ADB and EIB to develop their internal road safety action plans and has led multidisciplinary teams on numerous projects. He is also the author of several international guidelines and manuals on Road safety, Road safety action plans, Safety engineering, Road Safety Management, Safety audit, etc. Several of these have been translated into other languages and are now in widespread use around the world. His areas of specialist expertise include:

- Road safety management coordination and funding
- Performance indicators, Monitoring and evaluation
- Impacts and outcomes delivery
- Road safety strategies and Action plans
- Road safety engineering

He was the author of the ADB road safety audit toolkit and the main author of the TRL Red Book Towards Safer Roads - guidelines for engineers and planners on safety conscious planning and operation of roads. That document was translated into several languages and has been circulated and is in use in over 120 countries. He is now President of the International Road Safety Centre (IRSC), Belgrade a “not for profit” organization established to assist LMICs address road safety issues in all 5 pillars of the UN Decade of Action on Road Safety.

Dr Dejan Jovanov
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Dr Jovanov is a highly qualified road safety expert, with more than 20 years of experience in road safety. His theoretical background includes a Ph.D. in Transport and Traffic Engineering – Road Safety at state owned University of Belgrade. From the beginning of his carrier he was engaged in result oriented road safety project work. He has been employed in the Public Enterprise “Roads of Serbia” (i.e. the Roads Administration of Serbia) where he established the first Road Safety Unit and developed working procedures and activities and defined road safety strategy within the organization. In his career he has been a member of many different multidisciplinary consultancy teams undertaking international and regional road safety projects and has experience from 17 countries, mostly dealing with:

- Development of Road Safety Strategies and Action Plans,
- Improvement of laws and regulations to support new road safety tools (such as RSA, RSI, BSM, etc.) as a mandatory routine stipulated by EU Directive 96/2008,
- Road Safety Audits (including of preparations of Road Safety Audit Manuals, training curricula’s, training courses and certifications of trainers),
- Black Spot Management (including of preparations of Black Spot Management Guidelines, training curricula’s and training courses),
- Different Pilot Projects dedicated to road safety (education of children, media campaigns, local communities, RSA/RSI), etc.

Dr Jovanov is familiar with modern road safety tools and has capability of establishing a good contacts and transfer of knowledge to the Clients. He has a good overall knowledge of road traffic safety situation in the EU (SEETO)/Central Asian (TRACECA) countries. He is one of founders of IRSC.

Dipl. Ing. Hans Joachim Vollpracht
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Dipl. Ing. Hans-Joachim Vollpracht is a highly experience Roads Director General with 40 years of practice in road safety management. He has a Master's degree from Berlin and a Certificate in Management and Organization for leadership at the supreme technical state level. He has held leading positions in Western Berlin for roads and construction, was one of the German developers of traffic calming especially for vulnerable road users in cities. After reunification he held the position of head of the department for Roads and Traffic in the Ministry for Transport and Urban Development in the new German County of Brandenburg (around Berlin) for 13 years. Apart upgrading of 10.000 km of Motorways and Highways he initiated the first Road Safety Program in Eastern Germany, the first electronic accident investigation program and the implementation of Road Safety Audits in the design process with the result of 80% less fatalities in 20 years. He is a former Chairman of the Technical Committee for safer roads of the World Road Association (PIARC), has been a key speaker at many Road Safety events in 25 countries and has worked as Manager of several Road Safety projects in European, Asian and African countries mostly dealing with:

- Development of Road Safety Policy, Strategies and Action Plans,
- Improvement of laws and regulations to support new road safety tools (such as RSA, RSI, BSM, etc.) as a mandatory routine stipulated by EU Directive 96/2008,
- Road Safety Audits (including of preparations of Road Safety Audit Manuals, training curricula's, training courses and certifications of trainers),
- Network Safety Management (including of preparations of Black Spot Management Guidelines, training curricula's and training courses),
- Training of Traffic Police officers in accident investigations,
- Promotion of Human Factors in Road Design and operation into international road design standards by PIARC and
- Task Force member for the new PIARC Road Safety Manual.

Mr Vollpracht is familiar with the UN Global Plan for the Decade of Action for Road Safety and has established good contacts and transfer of knowledge to the different clients.

Rajko Brankovic
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Mr. Rajko Brankovic has fourteen years of work experience in road engineering and traffic management. He is dipl-ing in Transport and Traffic Engineering (University of Belgrade, Serbia) with specialization in traffic safety (Lund University in Sweden) and professional certificate in Road Safety Audit on European Road Network (University College of Dublin, Ireland). Throughout his professional career, he has worked in public authorities, private companies and as an international consultant. He has worked on large scale projects with different international financial organizations such as: World Bank, European Investment Bank, European Bank for Development and Reconstruction, European Union, etc. He has extensive international experience and knowledge of safety engineering issues and design standards from a range of countries including Ireland (UK), Sweden, Serbia, Ukraine, Moldova, Georgia, Azerbaijan, Armenia, Kazakhstan, Uzbekistan, Tajikistan, Kyrgyzstan, Republic of Macedonia and Qatar.
His expertise covers the following fields:

- Traffic Management on construction works,
- Traffic Design, Planning and Analysis,
- Road Safety Audit, Road Safety Inspection,
- Black Spot Management and Accident Investigation,
- Traffic safety condition surveys and
- Contracting and Procurement (World Bank, FIDIC, EU rules).

Currently, Mr Brankovic is working on the TRACECA Road Safety II in Euro-Asia Region as Safety Engineering Expert and Road Rehabilitation and Safety Project in Serbia as Head of Traffic Projects. Traffic management and traffic safety are his main areas of expertise.

Filip Trajkovic, M.Sc.
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Mr. Filip Trajkovic has five years of work experience in road engineering. He is MSc in Transport and Traffic Engineering (University of Belgrade, Serbia) with professional certificates for traffic design and supervision of Serbian Chamber of Engineers (certification no 370 and 470). Throughout his professional career, he has been working in consultancy companies and has provided inputs and gained experience of working on international projects mostly on Projects in Balkan Peninsula-SEETO organization region but also in region covered by TRACECA Road Safety II Project.
His expertise covers the following fields:

- Traffic Design, Planning and Analysis,
- Supervision in implementation of traffic signage and road equipment,
- Road Safety Audit, Road Safety Inspection,
- Black Spot Management and Accident Investigation and
- Traffic safety condition surveys.

Currently, Mr Trajkovic is working on the TRACECA Road Safety II in Euro-Asia Region as Traffic Engineer and on a major Road Rehabilitation and Safety Project in Serbia as Road Safety Engineer. Traffic designing/supervision, traffic analysis and traffic safety are his areas of specialist expertise.

IRSC is a NOT FOR PROFIT organisation which provides a platform for assisting Low and Middle Income Countries (LMICs) to address road safety issues in support of the UN Decade of Road Safety. It offers training, guidelines, manuals and training materials in all 5 pillars of road safety identified in the UN Decade of Road Safety.

- Safety management
- Safer roads
- Safer vehicles
- Safer road users
- Post crash systems

Sharing experience and expertise

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